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Takano et al.

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(54) **METHOD FOR PERFORMING HANDOVER, USER EQUIPMENT, BASE STATION, AND RADIO COMMUNICATION SYSTEM**

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(73) Assignee: **SONY CORPORATION**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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(63) Continuation of application No. 13/514,067, filed as application No. PCT/JP2010/007036 on Dec. 2, 2010, now Pat. No. 8,761,121.

(30) **Foreign Application Priority Data**

Dec. 16, 2009 (JP) 2009-285373

(51) **Int. Cl.**

H04W 72/08	(2009.01)
H04W 36/02	(2009.01)
H04W 36/30	(2009.01)
H04W 36/28	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 72/085*** (2013.01); ***H04W 36/02*** (2013.01); ***H04W 36/30*** (2013.01); *H04W 36/28* (2013.01)

(58) **Field of Classification Search**

USPC 370/331

See application file for complete search history.

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(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P

(57) **ABSTRACT**

According to embodiments, a base station includes a radio communication unit configured to establish communication with a mobile communication terminal using a plurality of component carriers. The base station further includes a control unit configured to transmit a command to the mobile communication terminal to reduce the plurality of component carriers to one prior to handover of communication between the mobile communication terminal and the base station to another base station.

19 Claims, 15 Drawing Sheets

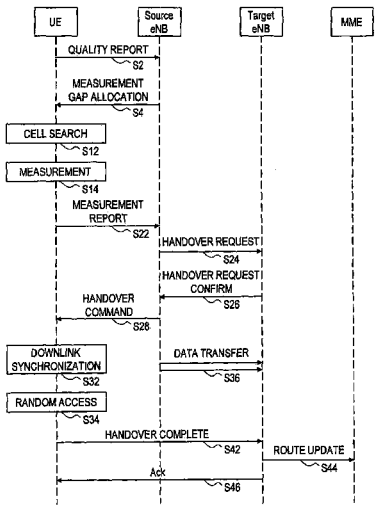

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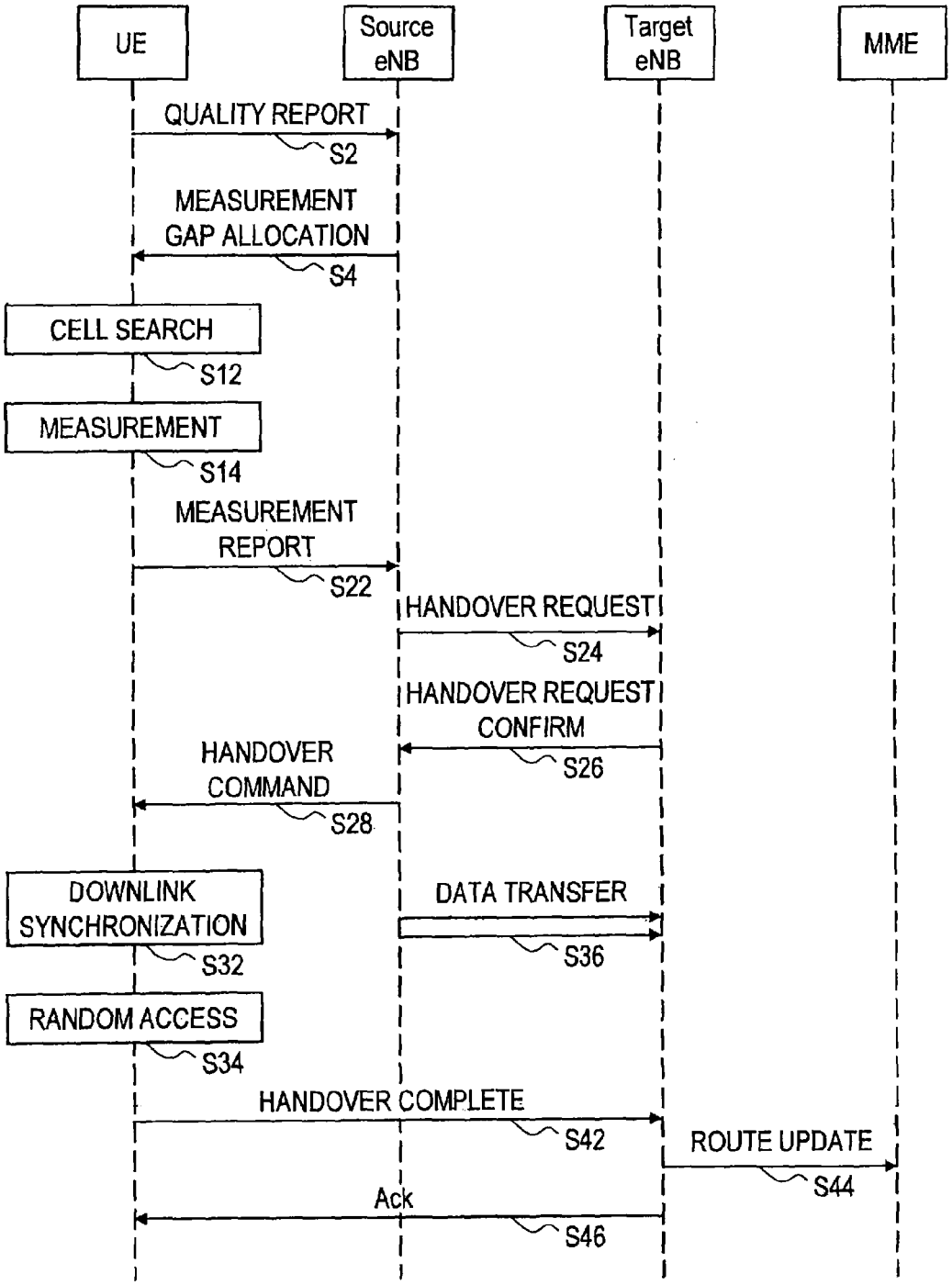
Fig. 1


UE
Source eNB
Target eNB
MME
QUALITY REPORT
S2
MEASUREMENT GAP ALLOCATION
S4
CELL SEARCH
S12
MEASUREMENT
S14
MEASUREMENT REPORT
S22
HANDOVER REQUEST
S24
HANDOVER REQUEST CONFIRM
S26
HANDOVER COMMAND
S28
DOWNLINK SYNCHRONIZATION
S32
DATA TRANSFER
S36
RANDOM ACCESS
S34
HANDOVER COMPLETE
S42
ROUTE UPDATE
S44
Ack
S46

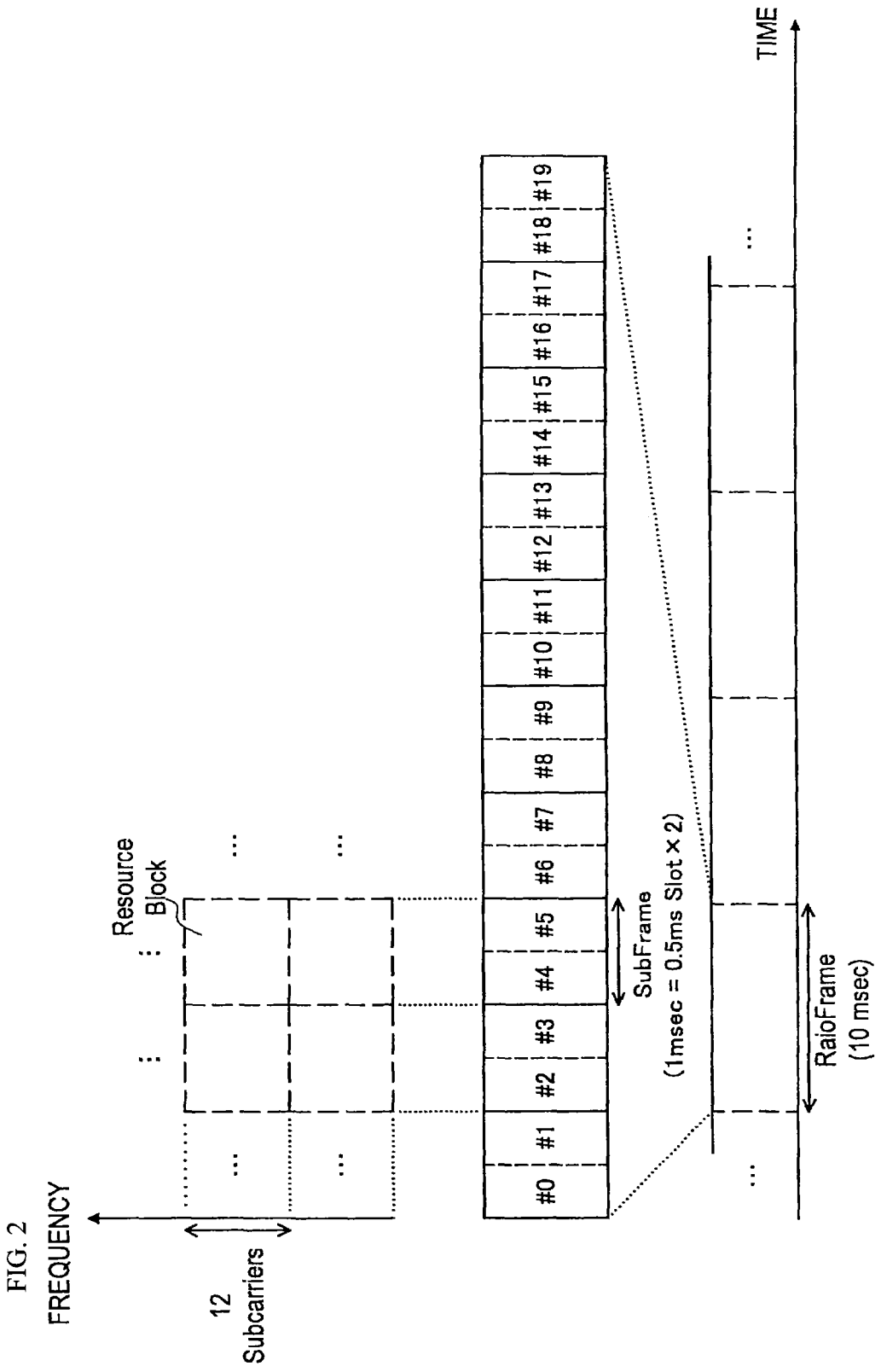

FREQUENCY
12 Subcarriers
Resource Block
#0
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12
#13
#14
#15
#16
#17
#18
#19
SubFrame
(1msec = 0.5ms Slot × 2)
TIME
RaioFrame
(10 msec)

FIG. 2

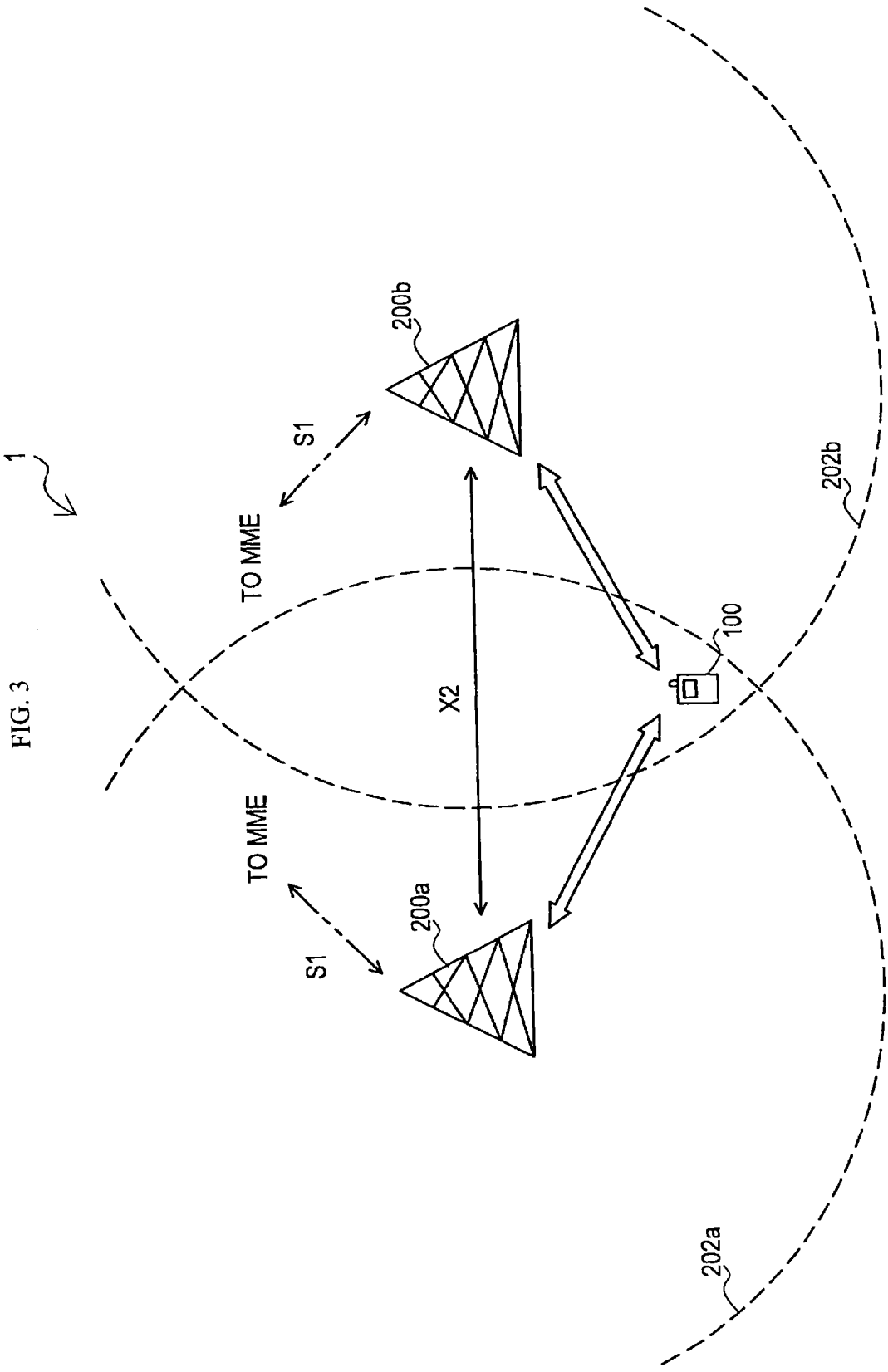


FIG. 3

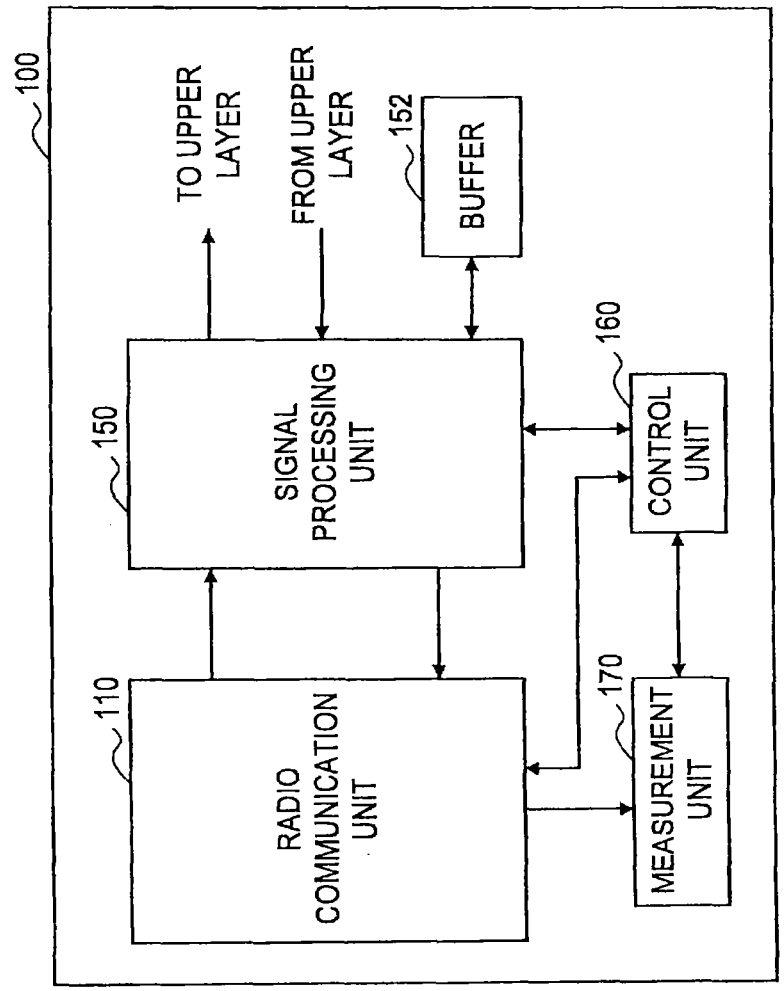
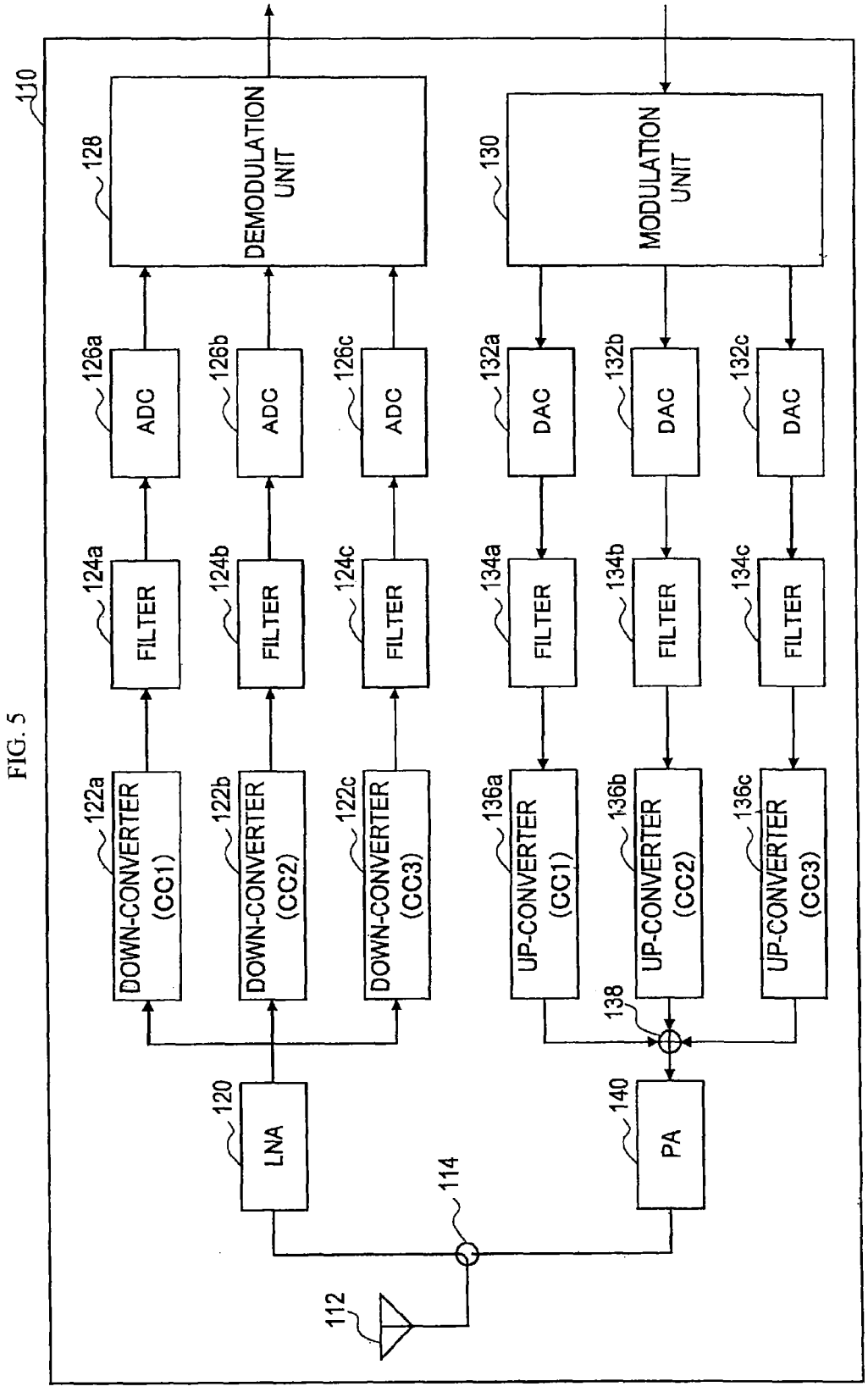

100
TO UPPER LAYER
FROM UPPER LAYER
152
BUFFER
160
150
SIGNAL PROCESSING UNIT
CONTROL UNIT
110
RADIO COMMUNICATION UNIT
170
MEASUREMENT UNIT

FIG. 4

FIG. 5


110
128
DEMODULATION UNIT
130
MODULATION UNIT
126a
ADC
126b
ADC
126c
ADC
132a
DAC
132b
DAC
132c
DAC
124a
FILTER
124b
FILTER
124c
FILTER
134a
FILTER
134b
FILTER
134c
FILTER
122a
DOWN-CONVERTER (CC1)
122b
DOWN-CONVERTER (CC2)
122c
DOWN-CONVERTER (CC3)
136a
UP-CONVERTER (CC1)
136b
UP-CONVERTER (CC2)
136c
UP-CONVERTER (CC3)
138
120
LNA
140
PA
114
112

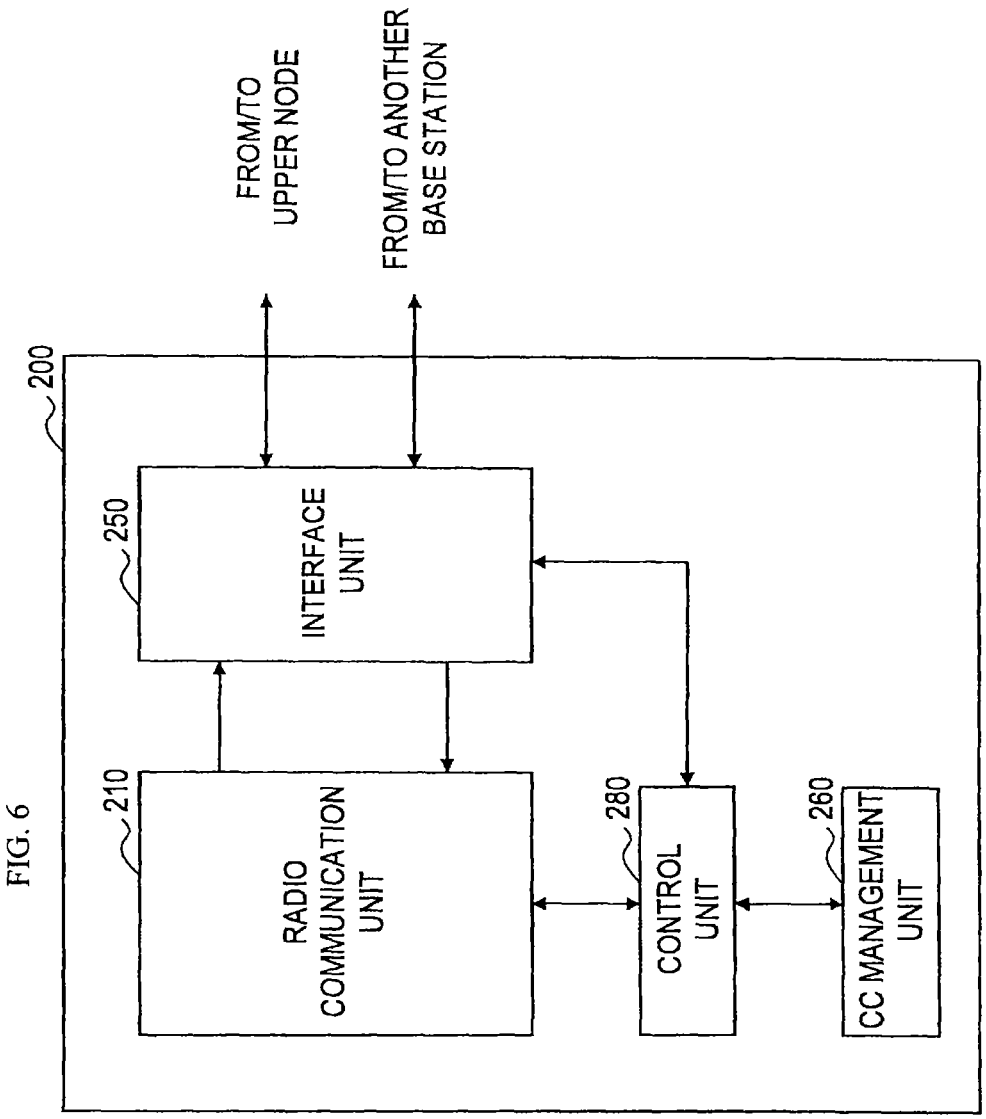

FROM/TO UPPER NODE
FROM/TO ANOTHER BASE STATION
200
250
INTERFACE UNIT
210
RADIO COMMUNICATION UNIT
280
CONTROL UNIT
260
CC MANAGEMENT UNIT

FIG. 6

Fig. 7

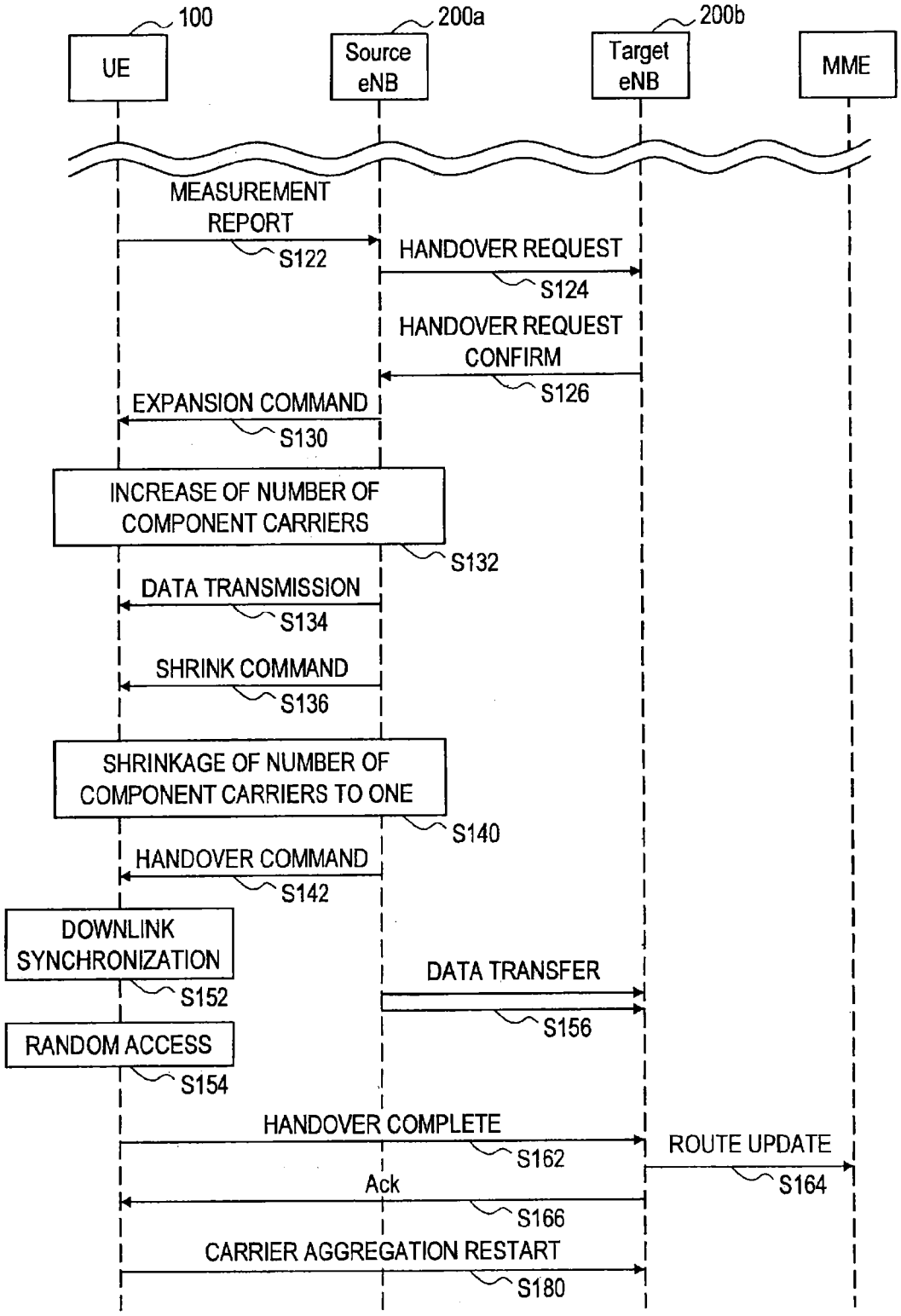
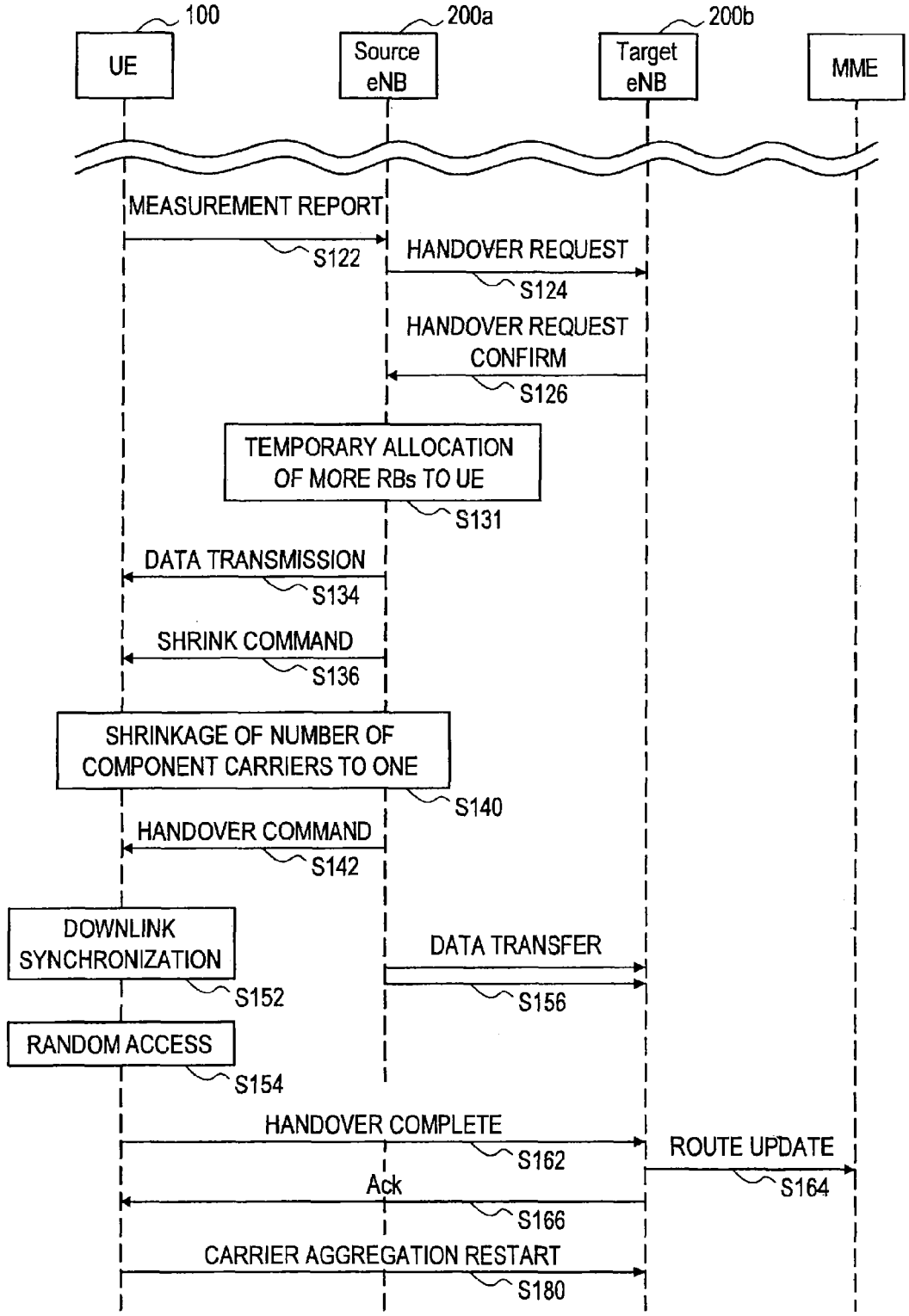

100
UE
200a
Source eNB
200b
Target eNB
MME
MEASUREMENT REPORT
S122
HANDOVER REQUEST
S124
HANDOVER REQUEST CONFIRM
S126
EXPANSION COMMAND
S130
INCREASE OF NUMBER OF COMPONENT CARRIERS
S132
DATA TRANSMISSION
S134
SHRINK COMMAND
S136
SHRINKAGE OF NUMBER OF COMPONENT CARRIERS TO ONE
S140
HANDOVER COMMAND
S142
DOWNLINK SYNCHRONIZATION
S152
DATA TRANSFER
S156
RANDOM ACCESS
S154
HANDOVER COMPLETE
S162
ROUTE UPDATE
S164
Ack
S166
CARRIER AGGREGATION RESTART
S180

Fig. 8


100
UE
200a
Source eNB
200b
Target eNB
MME
MEASUREMENT REPORT
S122
HANDOVER REQUEST
S124
HANDOVER REQUEST CONFIRM
S126
TEMPORARY ALLOCATION OF MORE RBs TO UE
S131
DATA TRANSMISSION
S134
SHRINK COMMAND
S136
SHRINKAGE OF NUMBER OF COMPONENT CARRIERS TO ONE
S140
HANDOVER COMMAND
S142
DOWNLINK SYNCHRONIZATION
S152
DATA TRANSFER
S156
RANDOM ACCESS
S154
HANDOVER COMPLETE
S162
ROUTE UPDATE
S164
Ack
S166
CARRIER AGGREGATION RESTART
S180

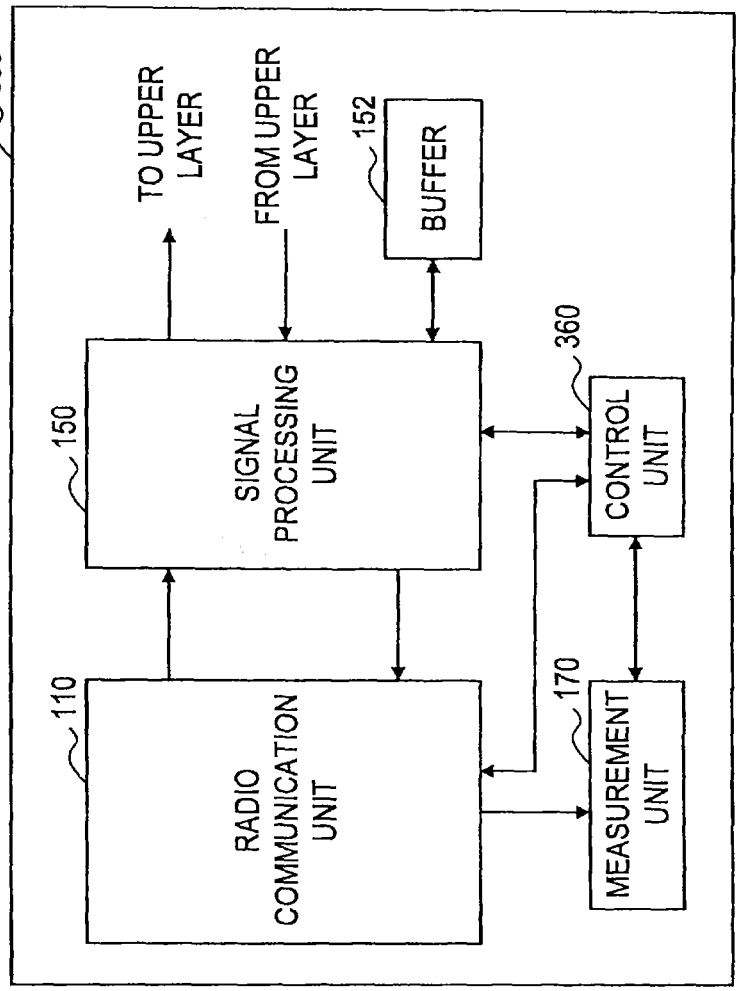

300
TO UPPER LAYER
FROM UPPER LAYER
152
BUFFER
150
SIGNAL PROCESSING UNIT
360
CONTROL UNIT
110
RADIO COMMUNICATION UNIT
170
MEASUREMENT UNIT

FIG. 9

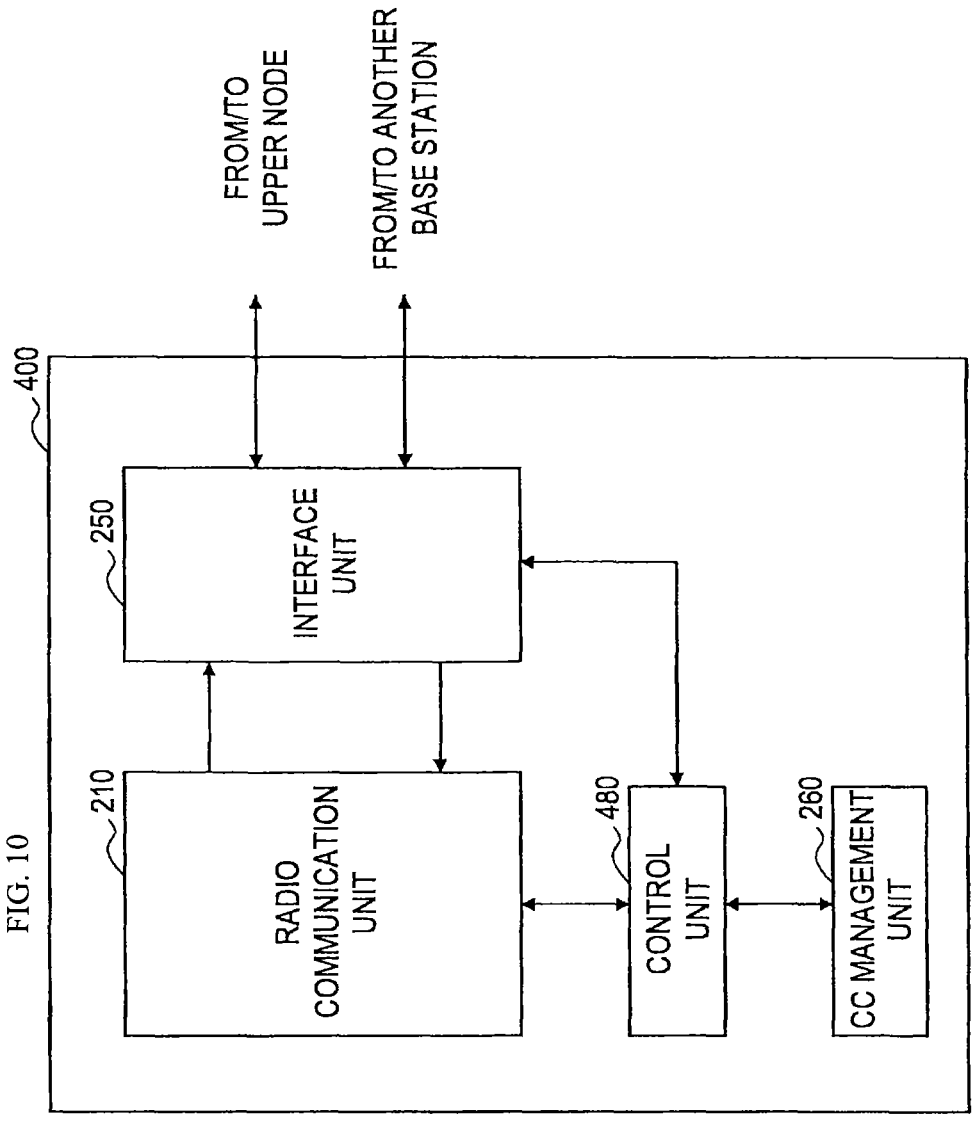

FROM/TO UPPER NODE
FROM/TO ANOTHER BASE STATION
400
250
INTERFACE UNIT
210
RADIO COMMUNICATION UNIT
480
CONTROL UNIT
260
CC MANAGEMENT UNIT

FIG. 10

Fig. 11

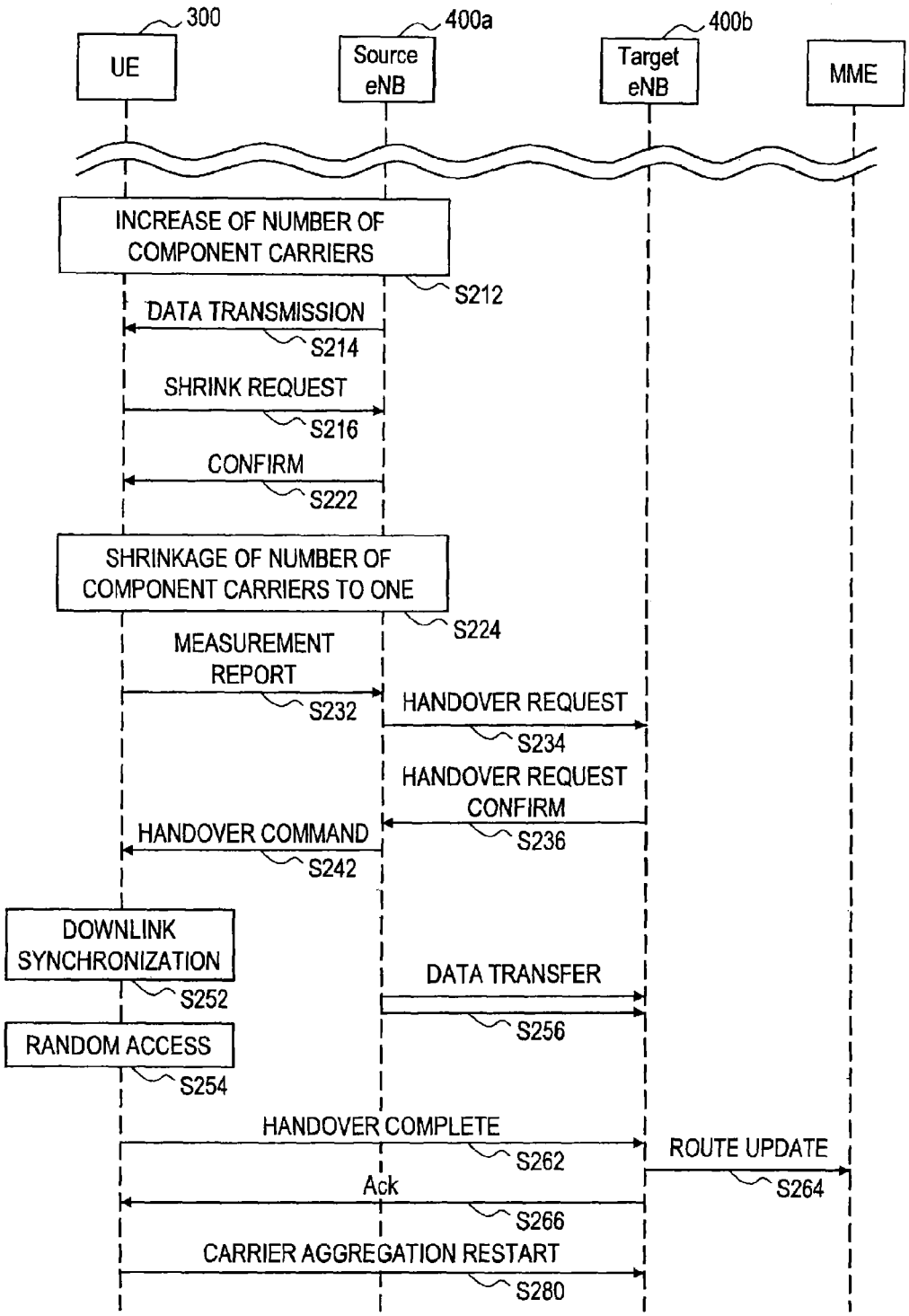
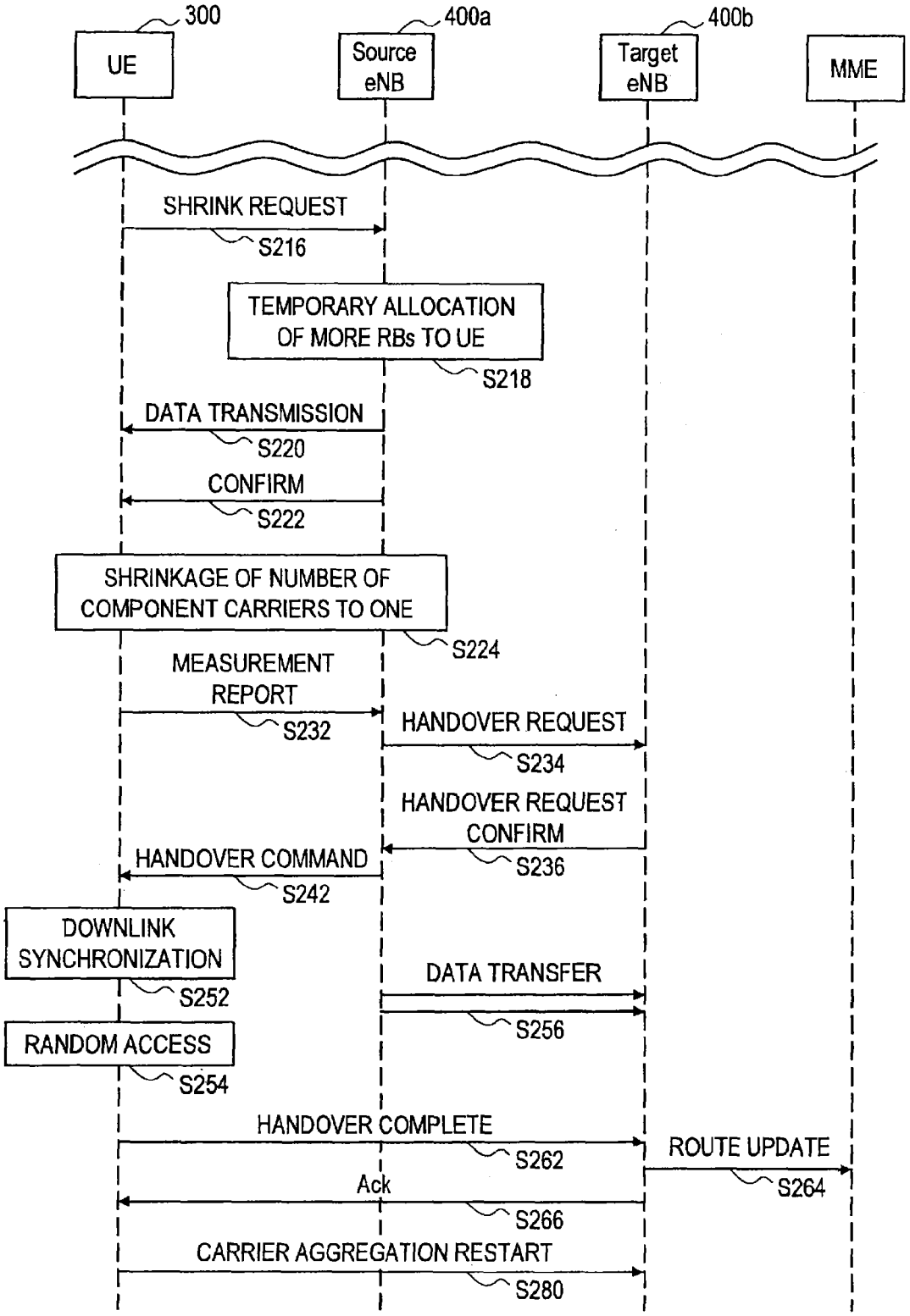

300
UE
400a
Source eNB
400b
Target eNB
MME
INCREASE OF NUMBER OF COMPONENT CARRIERS
S212
DATA TRANSMISSION
S214
SHRINK REQUEST
S216
CONFIRM
S222
SHRINKAGE OF NUMBER OF COMPONENT CARRIERS TO ONE
S224
MEASUREMENT REPORT
S232
HANDOVER REQUEST
S234
HANDOVER REQUEST CONFIRM
S236
HANDOVER COMMAND
S242
DOWNLINK SYNCHRONIZATION
S252
DATA TRANSFER
S256
RANDOM ACCESS
S254
HANDOVER COMPLETE
S262
ROUTE UPDATE
S264
Ack
S266
CARRIER AGGREGATION RESTART
S280

Fig. 12


300
UE
400a
Source eNB
400b
Target eNB
MME
SHRINK REQUEST
S216
TEMPORARY ALLOCATION OF MORE RBs TO UE
S218
DATA TRANSMISSION
S220
CONFIRM
S222
SHRINKAGE OF NUMBER OF COMPONENT CARRIERS TO ONE
S224
MEASUREMENT REPORT
S232
HANDOVER REQUEST
S234
HANDOVER REQUEST CONFIRM
S236
HANDOVER COMMAND
S242
DOWNLINK SYNCHRONIZATION
S252
DATA TRANSFER
S256
RANDOM ACCESS
S254
HANDOVER COMPLETE
S262
ROUTE UPDATE
S264
Ack
S266
CARRIER AGGREGATION RESTART
S280

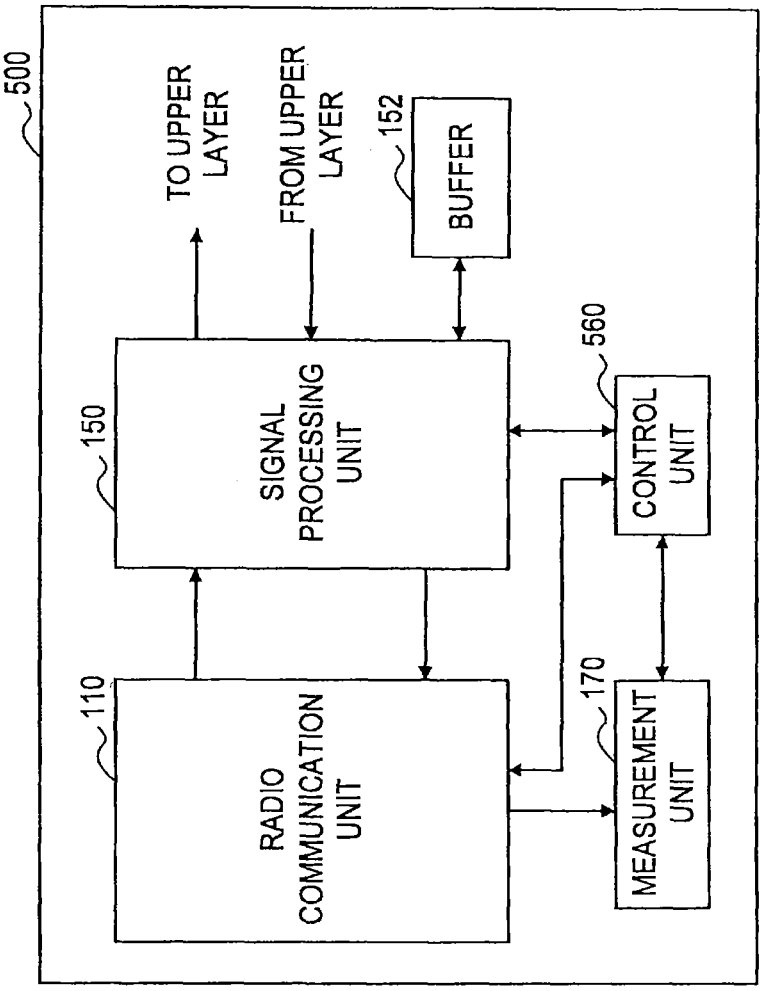

500
TO UPPER LAYER
FROM UPPER LAYER
152
BUFFER
560
150
SIGNAL PROCESSING UNIT
CONTROL UNIT
110
RADIO COMMUNICATION UNIT
170
MEASUREMENT UNIT

FIG. 13

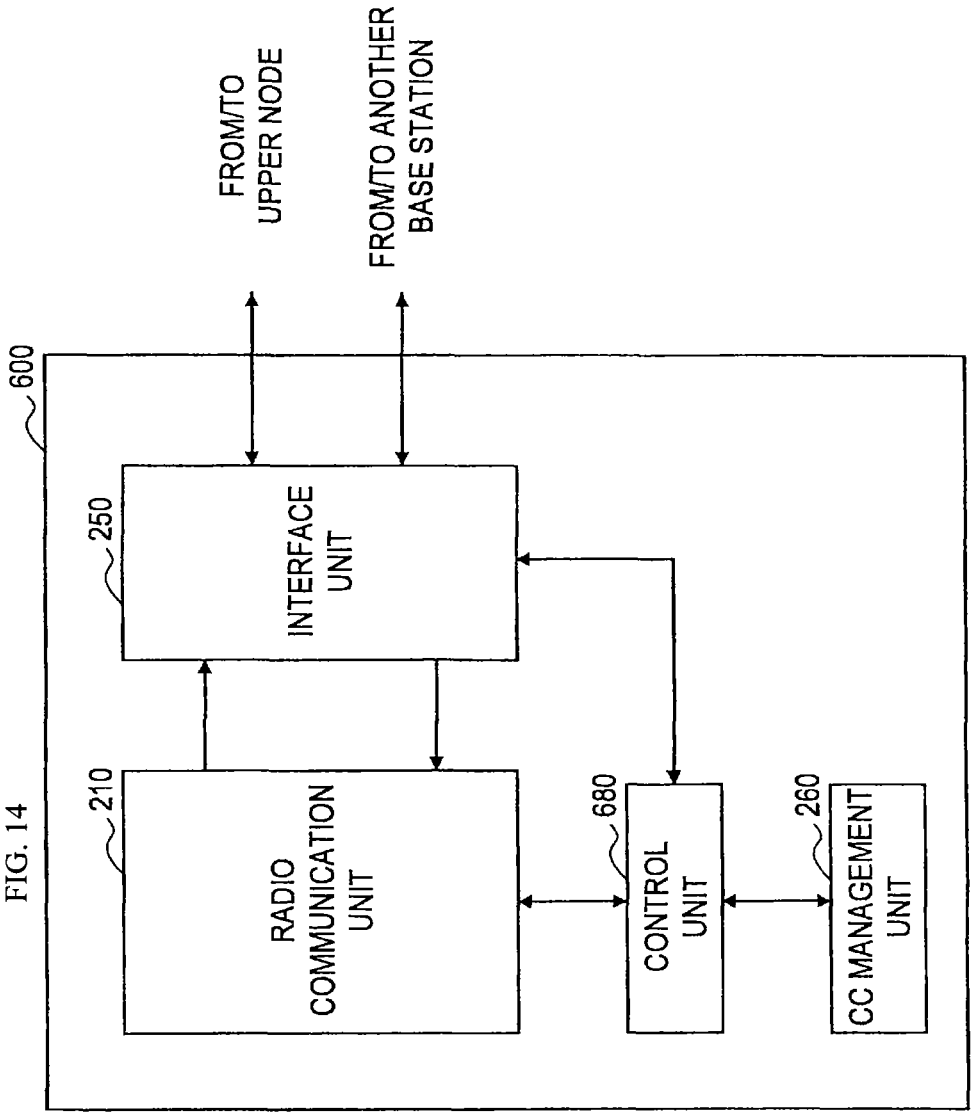
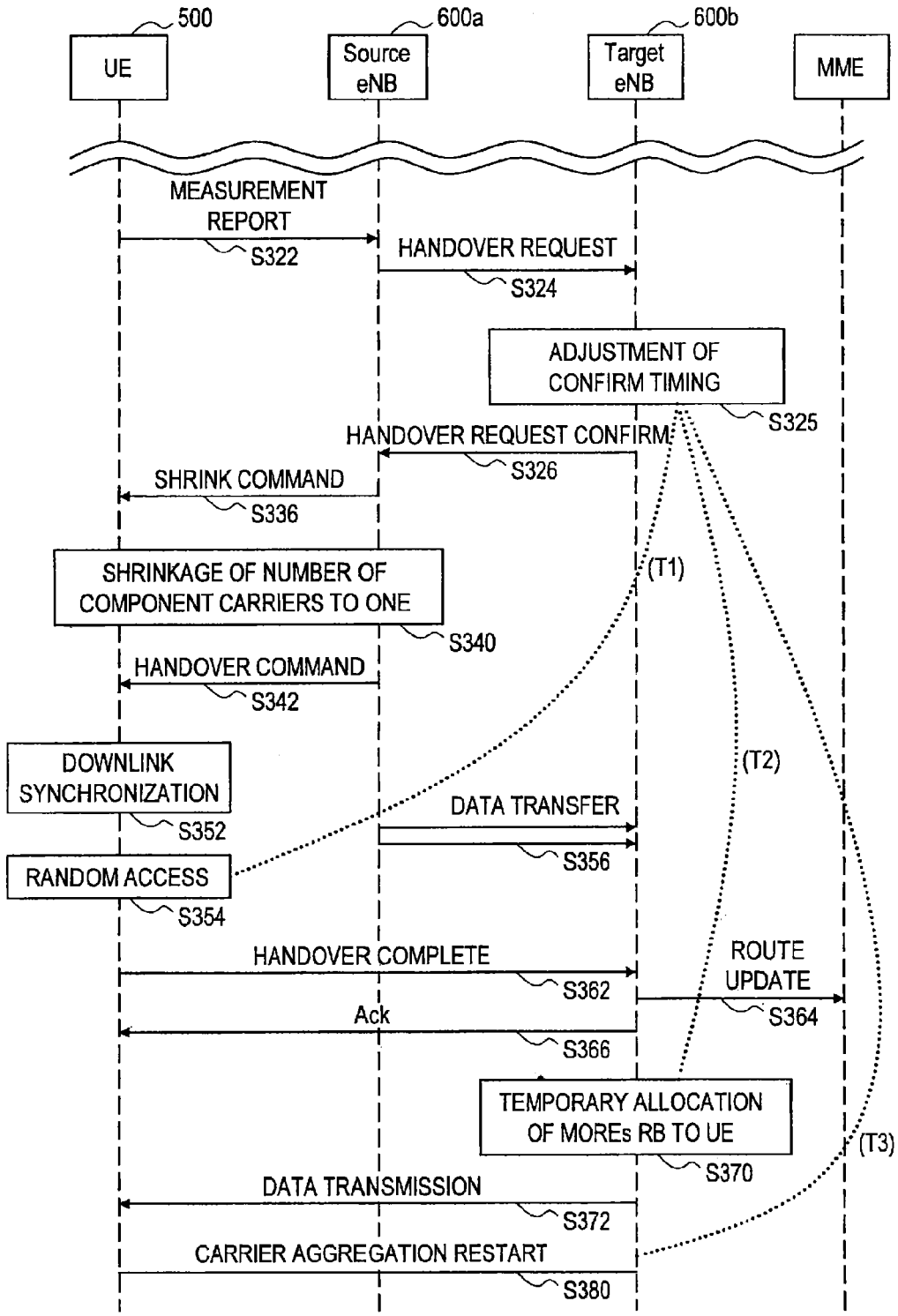

FROM/TO UPPER NODE
FROM/TO ANOTHER BASE STATION
600
250
INTERFACE UNIT
210
RADIO COMMUNICATION UNIT
680
CONTROL UNIT
260
CC MANAGEMENT UNIT

FIG. 14

Fig. 15


500
UE
600a
Source eNB
600b
Target eNB
MME
MEASUREMENT REPORT
S322
HANDOVER REQUEST
S324
ADJUSTMENT OF CONFIRM TIMING
S325
HANDOVER REQUEST CONFIRM
S326
SHRINK COMMAND
S336
SHRINKAGE OF NUMBER OF COMPONENT CARRIERS TO ONE
S340
HANDOVER COMMAND
S342
DOWNLINK SYNCHRONIZATION
S352
RANDOM ACCESS
S354
DATA TRANSFER
S356
HANDOVER COMPLETE
S362
ROUTE UPDATE
S364
Ack
S366
TEMPORARY ALLOCATION OF MOREs RB TO UE
S370
DATA TRANSMISSION
S372
CARRIER AGGREGATION RESTART
S380
(T1)
(T2)
(T3)

METHOD FOR PERFORMING HANDOVER, USER EQUIPMENT, BASE STATION, AND RADIO COMMUNICATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 13/514,067, filed Jun. 6, 2012, which is a National Stage of PCT/JP10/0736, filed Dec. 2, 2010 and claims the benefit of priority under 25 U.S.C. §119 of Japanese Application No. 2009-285373, filed Dec. 16, 2009. The entire contents of which of each is incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a method for performing a handover, a user equipment, a base station, and a radio communication system.

BACKGROUND ART

In Long Term Evolution-Advanced (LTE-A), which is the next-generation cellular communication standard that is discussed in Third Generation Partnership Project (3GPP), introduction of technology called carrier aggregation (CA) has been studied. The carrier aggregation is technology that forms a communication channel between a user equipment (UE) and a base station (BS, or evolved Node B (eNB)) by aggregating a plurality of frequency bands that are supported in LTE, for example, and thereby improves communication throughput. Each frequency band included in one communication channel by the carrier aggregation is called a component carrier (CC). The bandwidths of frequency bands that are available in LTE are 1.4 MHz, 3.0 MHz, 5.0 MHz, 10 MHz, 15 MHz, and 20 MHz. Accordingly, if five bands of 20 MHz are aggregated as component carriers, a communication channel of 100 MHz in total can be formed.

Component carriers that are included in one communication channel in the carrier aggregation are not necessarily contiguous to one another in the frequency direction. The mode in which component carriers are arranged contiguous to one another in the frequency direction is called a contiguous mode. On the other hand, the mode in which component carriers are arranged not contiguous to one another is called a non-contiguous mode.

Further, in the carrier aggregation, the number of component carriers in an uplink and the number of component carriers in a downlink are not necessarily equal. The mode in which the number of component carriers in an uplink and the number of component carriers in a downlink are equal is called a symmetric mode. On the other hand, the mode in which the number of component carriers in an uplink and the number of component carriers in a downlink are not equal is called an asymmetric mode. For example, in the case of using two component carriers in an uplink and three component carriers in a downlink, it is asymmetric carrier aggregation.

Further, in LTE, any one of frequency division duplex (FDD) and time division duplex (TDD) can be used as duplex operation. Because the direction of a link (uplink or downlink) of each component carrier does not change in time in FDD, FDD is better suited to the carrier aggregation compared to TDD.

A handover, which is a basic technique for achieving the mobility of a user equipment in the cellular communication standard, is one of important subjects in LTE-A. In LTE, a user equipment measures a communication quality over a channel with a serving base station (a currently connected base station) and communication qualities with peripheral base stations and transmits a measurement report containing measurements to the serving base station. Receiving the measurement report, the serving base station determines whether to execute a handover based on the measurements contained in the report. Then, if it is determined that a handover is to be executed, a handover is carried out among a source base station (the serving base station before a handover), the user equipment, and a target base station (a serving base station after a handover) in accordance with a prescribed procedure (e.g. cf. Patent Literature 1 below)

CITATION LIST

Patent Literature

[PTL 1]
Japanese Unexamined Patent Application Publication No. 2009-232293

SUMMARY OF INVENTION

Technical Problem

However, no case has been reported where active consideration is given to how to carry out a handover procedure in a radio communication involving the carrier aggregation.

In the above-described existing handover procedure, processing such as request for a handover, confirmation of the request, issue of a handover command or random access to a target base station is performed based on the assumption that one communication channel is composed of one component carrier. In a radio communication involving the carrier aggregation also, it is desirable to perform such processing in the same manner as the existing procedure in order not to cause a significant impact on a system or a device which is widely used today.

In light of the foregoing, it is desirable to provide a novel and improved method for performing a handover, user equipment, base station, and radio communication system that can carry out a handover during a radio communication involving the carrier aggregation without causing a significant impact on an existing system or device.

Solution to Problem

According to some embodiments, a base station includes a radio communication unit configured to establish communication with a mobile communication terminal using a plurality of component carriers. The base station further includes a control unit configured to transmit a command to the mobile communication terminal to reduce the plurality of component carriers to one prior to handover of communication between the mobile communication terminal and the base station to another base station.

According to some embodiments, a mobile communication terminal includes a radio communication unit configured to establish communication with a base station using a plurality of component carriers. The mobile communication terminal further includes a control unit configured to receive a command from the base station to reduce the plurality of component carriers to one prior to handover of communication between the mobile communication terminal and the base station to another base station.

According to some embodiments, a communication system includes a first base station and a mobile communication

terminal. The first base station includes a radio communication unit configured to establish communication with a mobile communication terminal using a plurality of component carriers. The first base station further includes a first control unit configured to transmit a command to the mobile communication terminal to reduce the plurality of component carriers to one prior to handover of communication between the mobile communication terminal and the base station to a second base station. The mobile communication terminal includes a second control unit configured to reduce the plurality of component carriers to one upon reception of the command from the first base station.

According to some embodiments, a non-transitory computer readable medium having instructions stored thereon, which when executed by a processor in a base station causes the processor to establish communication with a mobile communication terminal using a plurality of component carriers. The instructions further cause the processor to transmit a command to the mobile communication terminal to reduce the plurality of component carriers to one prior to handover of communication between the mobile communication terminal and the base station to another base station.

Advantageous Effects of Invention

As described above, the method for performing a handover, the user equipment, the base station, and the radio communication system according to the embodiments of the present invention can carry out a handover during a radio communication involving the carrier aggregation without causing a significant impact on an existing system or device.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a sequence chart to describe a flow of a typical handover procedure.

FIG. **2** is an explanatory view to describe an example of a structure of a communication resource.

FIG. **3** is a schematic view showing an outline of a radio communication system according to an embodiment.

FIG. **4** is a block diagram showing an example of a configuration of a user equipment according to a first embodiment.

FIG. **5** is a block diagram showing an example of a detailed configuration of a radio communication unit according to the first embodiment.

FIG. **6** is a block diagram showing an example of a configuration of a base station according to the first embodiment.

FIG. **7** is a sequence chart showing an example of a flow along a first scenario of a handover procedure according to the first embodiment.

FIG. **8** is a sequence chart showing an example of a flow along a second scenario of a handover procedure according to the first embodiment.

FIG. **9** is a block diagram showing an example of a configuration of a user equipment according to a second embodiment.

FIG. **10** is a block diagram showing an example of a configuration of a base station according to the second embodiment.

FIG. **11** is a sequence chart showing an example of a flow along a first scenario of a handover procedure according to the second embodiment.

FIG. **12** is a sequence chart showing an example of a flow along a second scenario of a handover procedure according to the second embodiment.

FIG. **13** is a block diagram showing an example of a configuration of a user equipment according to a third embodiment.

FIG. **14** is a block diagram showing an example of a configuration of a base station according to the third embodiment.

FIG. **15** is a sequence chart showing an example of a flow of a handover procedure according to the third embodiment.

DESCRIPTION OF EMBODIMENTS

Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the appended drawings. Note that, in this specification and the appended drawings, structural elements that have substantially the same function and structure are denoted with the same reference numerals, and repeated explanation of these structural elements is omitted.

Preferred embodiments of the present invention will be described hereinafter in the following order.

1. Description of Related Art
  1-1. Handover Procedure
  1-2. Structure of Communication Resource
2. Outline of Radio Communication System
3. Description of First Embodiment
  3-1. Exemplary Configuration of User Equipment
  3-2. Exemplary Configuration of Base Station
  3-3. Flow of Process
  3-4. Summary of First Embodiment
4. Description of Second Embodiment
  4-1. Exemplary Configuration of User Equipment
  4-2. Exemplary Configuration of Base Station
  4-3. Flow of Process
  4-4. Summary of Second Embodiment
5. Description of Third Embodiment
  5-1. Exemplary Configuration of User Equipment
  5-2. Exemplary Configuration of Base Station
  5-3. Flow of Process
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1. Description of Related Art

(1-1. Handover Procedure)

A technique related to the present invention is described hereinafter with reference to FIGS. **1** and **2**. FIG. **1** shows a flow of a handover procedure in conformity with LTE in a radio communication not involving the carrier aggregation as an example of a typical handover procedure. In this example, a user equipment (UE), a source base station (source eNB), a target base station (target eNB), and a mobility management entity (MME) are involved in the handover procedure.

As a preliminary step toward a handover, the user equipment first reports the channel quality of a communication channel between the user equipment and the source base station to the source base station (step S**2**). The channel quality may be reported on a regular basis or when the channel quality falls below a predetermined reference value. The user equipment can measure the channel quality of the communication channel with the source base station by receiving a reference signal contained in a downlink channel from the source base station.

Then, the source base station determines the needs of measurement based on the quality report received from the user equipment and, if measurement is necessary, allocates measurement gaps to the user equipment (step S**4**).

Then, the user equipment searches for a downlink channel from a peripheral base station (i.e. performs cell search) dur-

ing the periods of the allocated measurement gaps (step S12). Note that the user equipment can recognize a peripheral base station to search according to a list that is provided in advance from the source base station.

When the user equipment acquires synchronization with a downlink channel, the user equipment performs measurement by using a reference signal contained in the downlink channel (step S14). During this period, the source base station restricts an allocation of data communication related to the user equipment so as to avoid occurrence of data transmission by the user equipment.

Upon completion of the measurement, the user equipment transmits a measurement report containing measurements to the source base station (step S22). The measurements contained in the measurement report may be the average value or the central value of measured values over a plurality of times of measurement or the like. Further, the measurements may contain data about a plurality of frequency bands.

Receiving the measurement report, the source base station determines whether or not to execute a handover based on the contents of the measurement report. For example, when the channel quality of another base station in the periphery is higher than the channel quality of the source base station by a predetermined threshold or greater, it can be determined that a handover is necessary. In this case, the source base station determines to carry out a handover procedure with the relevant another base station as a target base station, and transmits a handover request message to the target base station (step S24).

Receiving the handover request message, the target base station determines whether it is possible to accept the user equipment according to the availability of a communication service offered by itself or the like. When it is possible to accept the user equipment, the target base station transmits a handover request confirm message to the source base station (step S26).

Receiving the handover request confirm message, the source base station transmits a handover command to the user equipment (step S28). Then, the user equipment acquires synchronization with the downlink channel of the target base station (step S32). After that, the user equipment makes a random access to the target base station by using a random access channel in a given time slot (step S34). During this period, the source base station forwards data addressed to the user equipment to the target base station (step S36). Then, after success in the random access, the user equipment transmits a handover complete message to the target base station (step S42).

Receiving the handover complete message, the target base station requests the MME to perform route update for the user equipment (step S44). Upon updating the route of user data by the MME, the user equipment becomes able to communicate with another device through a new base station (i.e. the target base station). Then, the target base station transmits acknowledgement to the user equipment (step S46). A series of handover procedure thereby ends.

(1-2. Structure of Communication Resource)

FIG. 2 shows a structure of a communication resource in LTE as an example of a structure of a communication resource to which the present invention is applicable. Referring to FIG. 2, the communication resource in LTE is segmented in the time direction into radio frames each having a length of 10 msec. One radio frame includes ten sub-frames, and one sub-frame is made up of two 0.5 msec slots. In LTE, the sub-frame is one unit of an allocation of a communication resource to each user equipment in the time direction. Such one unit is called a resource block. One resource block includes twelve sub-carriers in the frequency direction. Specifically, one resource block has a size of 1 msec with 12 sub-carriers in the time-frequency domain. Throughput of data communication increases as a larger number of resource blocks are allocated for data communication on condition of the same bandwidth and time length. Further, in such a structure of a communication resource, a part of radio frame with a given frequency band is reserved as a random access channel. The random access channel can be used for an access to a base station by a user equipment that has changed from an idle mode to an active mode or an initial access to a target base station in a handover procedure, for example.

2. Outline of Radio Communication System

FIG. 3 is a schematic view showing an outline of a radio communication system 1 according to an embodiment of the present invention. Referring to FIG. 3, the radio communication system 1 includes a user equipment 100, a base station 200*a* and a base station 200*b*. It is assumed that the base station 200*a* is a serving base station for the user equipment 100.

The user equipment 100 is located inside a cell 202*a* where a radio communication service is provided by the base station 200*a*. The user equipment 100 can perform a data communication with another user equipment (not shown) via the base station 200*a* over a communication channel formed by aggregating a plurality of component carriers (i.e. by carrier aggregation). However, because the distance between the user equipment 100 and the base station 200*a* is not short, there is a possibility that a handover is required for the user equipment 100. Further, the user equipment 100 is located inside a cell 202*b* where a radio communication service is provided by the base station 200*b*. Therefore, the base station 200*b* can be a candidate for a target base station for a handover of the user equipment 100.

The base station 200*a* can communicate with the base station 200*b* through a backhaul link (e.g. X2 interface). Various kinds of messages in the handover procedure as described with reference to FIG. 1, scheduling information related to the user equipment belonging to each cell or the like, for example, can be transmitted and received between the base station 200*a* and the base station 200*b*. Further, the base station 200*a* and the base station 200*b* can communicate with the MME, which is an upper node, through S1 interface, for example.

It is now assumed that the necessity of a handover to the base station 200*b* arises while the user equipment 100 performs a radio communication involving the carrier aggregation with the base station 200*a*. In this case, as a way to carry out a handover among the user equipment 100, the base station 200*a* and the base station 200*b* without largely altering the existing handover procedure described with reference to FIG. 1, the number of component carriers constituent of a communication channel may be shrunk temporarily. Shrinking the number of component carriers means reducing the number of component carriers constituent of one communication channel by the carrier aggregation technology. For example, if the number of component carriers is temporarily shrunk to one, a handover can be carrier out according to the same procedure as the existing handover procedure. However, the reduction of the number of component carriers can cause a temporary decrease in throughput. The decrease in throughput raises the possibility of the occurrence of buffer under flow at the receiving end of data or buffer over flow at the transmitting end of data, which can lead to a failure of a communication service such as contents delivery. Therefore,

in the case of temporarily shrinking the number of component carriers, it is effective to avoid or reduce the above-described possibility due to a decrease in throughput as much as possible as in the first to third embodiments of the present invention which are described in detail in the following sections.

It should be noted that, when there is no particular need to distinguish between the base station **200***a* and the base station **200***b* in the following description of the specification, they are collectively referred to as a base station **200** by omitting the alphabetical letter at the end of the reference symbol. The same applies to the other elements.

3. Description of First Embodiment

A first embodiment of the present invention is described hereinafter with reference to FIGS. **4** to **8**.

(3-1. Exemplary Configuration of User Equipment)

FIG. **4** is a block diagram showing an example of a configuration of the user equipment **100** according to the embodiment. Referring to FIG. **4**, the user equipment **100** includes a radio communication unit **110**, a signal processing unit **150**, a buffer **152**, a control unit **160**, and a measurement unit **170**.

(Radio Communication Unit)

The radio communication unit **110** performs a radio communication with the base station **200** over a communication channel formed by aggregating a plurality of component carriers with use of the carrier aggregation technology.

FIG. **5** is a block diagram showing an example of a more detailed configuration of the radio communication unit **110**. Referring to FIG. **5**, the radio communication unit **110** includes an antenna **112**, a switch **114**, a low noise amplifier (LNA) **120**, a plurality of down-converters **122***a* to **122***c*, a plurality of filters **124***a* to **124***c*, a plurality of analogue-to-digital converters (ADCs) **126***a* to **126***c*, a demodulation unit **128**, a modulation unit **130**, a plurality of digital-to-analogue converters (DACs) **132***a* to **132***c*, a plurality of filters **134***a* to **134***c*, a plurality of up-converters **136***a* to **136***c*, a combiner **138**, and a power amplifier (PA) **140**.

The antenna **112** receives a radio signal transmitted from the base station **200** and outputs the received signal to the LNA **120** through the switch **114**. The LNA **120** amplifies the received signal. The down-converter **122***a* and the filter **124***a* separate a baseband signal of the first component carrier (CC1) from the received signal amplified by the LNA **120**. Then, the separated baseband signal is converted to a digital signal by the ADC **126***a* and output to the demodulation unit **128**. Likewise, the down-converter **122***b* and the filter **124***b* separate a baseband signal of the second component carrier (CC2) from the received signal amplified by the LNA **120**. Then, the separated baseband signal is converted to a digital signal by the ADC **126***b* and output to the demodulation unit **128**. Further, the down-converter **122***c* and the filter **124***c* separate a baseband signal of the third component carrier (CC3) from the received signal amplified by the LNA **120**. Then, the separated baseband signal is converted to a digital signal by the ADC **126***c* and output to the demodulation unit **128**. After that, the demodulation unit **128** generates a data signal by demodulating the baseband signals of the respective component carriers and outputs the data signal to the signal processing unit **150**.

Further, when a data signal is input from the signal processing unit **150**, the modulation unit **130** modulates the data signal and generates baseband signals of the respective component carriers. Among those baseband signals, the baseband signal of the first component carrier (CC1) is converted to an analog signal by the DAC **132***a*. Then, a frequency component corresponding to the first component carrier in a transmission signal is generated from the analog signal by the filter **134***a* and the up-converter **136***a*. Likewise, the baseband signal of the second component carrier (CC2) is converted to an analog signal by the DAC **132***b*. Then, a frequency component corresponding to the second component carrier in the transmission signal is generated from the analog signal by the filter **134***b* and the up-converter **136***b*. Further, the baseband signal of the third component carrier (CC3) is converted to an analog signal by the DAC **132***c*. Then, a frequency component corresponding to the third component carrier in the transmission signal is generated from the analog signal by the filter **134***c* and the up-converter **136***c*. After that, the generated frequency components corresponding to the three component carriers are combined by the combiner **138**, and the transmission signal is formed. The PA **140** amplifiers the transmission signal and outputs the transmission signal to the antenna **112** through the switch **114**. Then, the antenna **112** transmits the transmission signal as a radio signal to the base station **200**.

Although the case where the radio communication unit **110** handles three component carriers is described in FIG. **5**, the number of component carriers handled by the radio communication unit **110** may be two, or four or more.

Further, instead of processing the signals of the respective component carriers in the analog region as in the example of FIG. **5**, the radio communication unit **110** may process the signals of the respective component carriers in the digital region. In the latter case, at the time of reception, a digital signal converted by one ADC is separated into the signals of the respective component carriers by a digital filter. Further, at the time of transmission, after digital signals of the respective component carriers are frequency-converted and combined, the signal is converted into an analog signal by one DAC. The load of the ADC and the DAC is generally smaller when processing the signals of the respective component carriers in the analog region. On the other hand, when processing the signals of the respective component carriers in the digital region, a sampling frequency for AD/DA conversion is higher, and the load of the ADC and the DAC can thereby increase.

(Signal Processing Unit)

Referring back to FIG. **4**, an example of a configuration of the user equipment **100** is further described below.

The signal processing unit **150** performs signal processing such as deinterleaving, decoding or error correction on the demodulated data signal that is input from the radio communication unit **110**. Then, the signal processing unit **150** outputs the processed data signal to an upper layer. Note that the signal processing unit **150** performs buffer control of data signals by using the buffer **152**. Specifically, the signal processing unit **150** stores processed data signals into the buffer **152** once and then outputs the data signal to an upper layer, following the first-in first-out (FIFO) rule, for example. Thus, when the data signals are input at a rate exceeding a normal data rate of a communication service, the amount of data accumulated in the buffer **152** increases. Further, when the input rate of the data signals decreases, the amount of data accumulated in the buffer **152** decreases. Further, the signal processing unit **150** performs signal processing such as encoding or interleaving on the data signal that is input from the upper layer. In this case also, the signal processing unit **150** may perform buffer control of data signals by using the buffer **152**. Then, the signal processing unit **150** outputs the processed data signals to the radio communication unit **110**.

(Buffer)

The buffer **152** temporarily accumulates the data signals that are input from the signal processing unit **150** by using a

storage medium such as a hard disk or semiconductor memory. The data signals are read following the first-in first-out rule, for example, and processed by the signal processing unit **150**.

(Control Unit)

According to some embodiments, the control unit is further configured to restart use of the plurality of component carriers after completion of the handover. In further embodiments, the control unit is further configured to receive a command from the base station to increase data throughput of the communication between the mobile communication terminal and the base station prior to reception of the command to reduce the plurality of component carriers to one. In additional embodiments, the command from the base station to increase the data throughput instructs the control unit to increase the plurality of component carriers used between the base station and mobile communication terminal.

The control unit **160** controls the overall functions of the user equipment **100** by using a processing device such as a central processing unit (CPU) or a digital signal processor (DSP). For example, the control unit **160** controls the timing of data communication by the radio communication unit **110** according to scheduling information that is received from the base station **200** by the radio communication unit **110**. Further, the control unit **160** increases or decreases the number of component carriers constituent of the communication channel with the base station **200** according to a command from the base station **200**. For example, when an expansion (increase) command of the number of component carriers is received from the base station **200**, the control unit **160** increases the number of component carriers. Further, when a shrink command of the number of component carriers is received from the base station **200**, the control unit **160** decreases the number of component carriers. Besides, the control unit **160** controls the user equipment **100** to operate in the same manner as the user equipment in the handover procedure which is descried with reference to FIG. **1**.

(Measurement Unit)

The measurement unit **170** measures the channel quality for each of the component carriers by using a reference signal from the base station **200** according to control from the control unit **160**, for example. Further, the measurement unit **170** executes measurement for a handover with respect to each of the component carriers by using the measurement gaps which are allocated by the base station **200**. A result of the measurement executed by the measurement unit **170** is converted to a predetermined format for a measurement report by the control unit **160** and transmitted to the base station **200** through the radio communication unit **110**. After that, the base station **200** determines, based on the measurement report, whether a handover should be executed or not for the user equipment **100**.

(3-2. Exemplary Configuration of Base Station)

FIG. **6** is a block diagram showing an example of a configuration of the base station **200** according to the embodiment. Referring to FIG. **6**, the base station **200** includes a radio communication unit **210**, an interface unit **250**, a component carrier (CC) management unit **260**, and a control unit **280**.

(Radio Communication Unit)

A specific configuration of the radio communication unit **210** may be similar to the configuration of the radio communication unit **110** of the user equipment **100** which is described above with reference to FIG. **5**, although the number of component carriers to be supported, the requirements of processing performance or the like are different. The radio communication unit **210** performs a radio communication with the user equipment over a communication channel which is formed by aggregating a plurality of component carriers with use of the carrier aggregation technology.

(Interface Unit)

The interface unit **250** mediates a communication between the radio communication unit **210** or the control unit **280** and an upper node through the S1 interface illustrated in FIG. **3**, for example. Further, the interface unit **250** mediates a communication between the radio communication unit **210** or the control unit **280** and another base station through the X2 interface illustrated in FIG. **3**, for example.

(CC Management Unit)

The CC management unit **260** holds data that indicates which component carrier each user equipment is using for communication with respect to each of the user equipments belonging to the cell of the base station **200**. Such data can be updated by the control unit **280** when an additional user equipment joins the cell of the base station **200** or when the connected user equipment changes its component carriers. Thus, the control unit **280** can recognize which component carrier the user equipment **100** is using by referring to the data held by the CC management unit **260**.

(Control Unit)

According to some embodiments, the control unit is further configured to increase data throughput of the communication between the mobile communication terminal and the base station prior to transmitting the command to reduce the plurality of component carriers to one. In further embodiments, the control unit is further configured to transmit a command to the mobile communication terminal to increase the plurality of component carriers used between the base station and mobile communication terminal to increase the data throughput. In additional embodiments, the control unit is further configured to increase one or more resource blocks to be allocated to the mobile communication terminal in at least one component carrier from the plurality of component carriers to increase the data throughput.

The control unit **280** controls the overall functions of the base station **200** by using a processing device such as a CPU or a DSP. For example, the control unit **280** allocates communication resources for data communication to the user equipment **100** and other user equipments and then delivers scheduling information over a broadcast channel in a given sub-frame.

Further, in this embodiment, in the case where the base station **200** is a source base station, when a handover request is confirmed by a target base station, the control unit **280** temporarily increases the amount of communication resources to be allocated to the user equipment **100**. The control unit **280** may increase the above-described amount of communication resources by increasing the number of component carriers constituent of the communication channel with the user equipment **100**, for example. The number of component carriers can be increased by transmitting an expansion command of the number of component carriers to the user equipment **100**, for example. Alternatively, the control unit **280** may increase the above-described amount of communication resources by increasing the number of resource blocks to be allocated to the user equipment **100** in at least one component carrier. After the control unit **280** transmits/receives data to/from the user equipment **100** at a higher rate than usual by using the communication resources which are increased in this manner, before transmitting a handover command to the user equipment **100**, the control unit **280** transmits a shrink command of the number of component carriers to the user equipment **100**. The number of component carriers constituent of the communication channel between

the user equipment **100** and the base station **200** is thereby shrunk to one. Then, the control unit **280** transmits a handover command for one component carrier after the shrinkage to the user equipment **100**.

Further, in the case where the base station **200** is a target base station, when a handover by the user equipment **100** is completed, the control unit **280** restarts the radio communication involving the carrier aggregation by the user equipment **100** in response to a request from the user equipment **100**. Besides, the control unit **280** controls the base station **200** to operate in the same manner as the source base station or the target base station in the handover procedure which is descried with reference to FIG. **1**.

(3-3. Flow of Process)

Two scenarios of a handover procedure according to the embodiment are described hereinbelow. Note that, in the following scenarios, it is assumed that a handover procedure is performed among the user equipment **100**, the base station **200***a* serving as a source base station, and the base station **200***b* serving as a target base station. Further, for the procedure up to measurement in the user equipment (steps S**2** to S**14**) in the typical handover procedure illustrated in FIG. **1**, explanation is omitted because there is no significant difference.

FIG. **7** is a sequence chart showing an example of a flow along the first scenario of a handover procedure according to the embodiment. Referring to FIG. **7**, the user equipment **100** first transmits a measurement report for a plurality of component carriers constituent of a communication channel to the base station **200***a* (step S**122**). Receiving the measurement report, the base station **200***a* determines the necessity of a handover based on the measurement report. For example, when a channel quality between the user equipment **100** and the base station **200***b* is better than a channel quality between the user equipment **100** and the base station **200***a* by a predetermined threshold or greater in any component carrier, it can be determined that a handover is necessary. In this case, the base station **200***a* transmits a handover request message to the base station **200***b* (step S**124**). Receiving the handover request message, the base station **200***b* determines whether it is possible to accept the user equipment **100** according to the availability of a communication service offered by itself or the like. When the base station **200***b* determines that it is possible to accept the user equipment **100**, the base station **200***b* transmits a handover request confirm message to the base station **200***a* (step S**126**).

Receiving the handover request confirm message, the base station **200***a* transmits an expansion command for increasing the number of component carriers to the user equipment **100** (step S**130**). In response thereto, the user equipment **100** makes a random access to the base station **200***a* for a new component carrier to establish a communication channel with the base station **200***a* and thereby increases the number of component carriers (step S**132**). After that, the base station **200***a* transmits data to the user equipment **100** at a rate exceeding a normal data rate over the expanded communication channel (step S**134**). The transmitted data is temporarily accumulated in the buffer **152** of the user equipment **100**.

Then, the base station **200***a* transmits a shrink command for decreasing the number of component carriers to the user equipment **100** (step S**136**). In response thereto, the user equipment **100** shrinks the number of component carriers constituent of the communication channel with the base station **200***a* to one (step S**140**). The base station **200***a* then transmits a handover command for one component carrier after the shrinkage to the user equipment **100** (step S**142**).

Receiving the handover command, the user equipment **100** acquires synchronization with the downlink channel of the base station **200***b* (step S**152**). Then, the user equipment **100** makes a random access to the base station **200***b* by using a random access channel in a given time slot of the synchronized downlink channel (step S**154**). During this period, the base station **200***a* forwards data addressed to the user equipment **100** to the base station **200***b* (step S**156**). Then, after success in the random access, the user equipment **100** transmits a handover complete message to the base station **200***b* (step S**162**). Receiving the handover complete message, the base station **200***b* requests the MME to perform route update for the user equipment **100** (step S**164**). Upon updating the route of user data by the MME, the user equipment **100** becomes able to communicate with another device through a new base station (i.e. the base station **200***b*). Then, the base station **200***b* transmits acknowledgement for the handover complete message to the user equipment **100** (step S**166**).

After that, the user equipment **100** restarts the radio communication involving the carrier aggregation with the base station **200***b*, which is a new serving base station (step S**180**). Specifically, the user equipment **100** makes a random access to the base station **200***b* for an additional component carrier to establish a communication channel with the base station **200***b*, for example, and thereby increases the number of component carriers. It is thereby possible in the user equipment **100** to use the communication service again at substantially the same data rate as that before the start of the handover procedure.

FIG. **8** is a sequence chart showing an example of a flow along the second scenario of a handover procedure according to the embodiment. As is understood from comparison between FIG. **7** and FIG. **8**, in the second scenario, the steps S**130** and S**132** in the first scenario are replaced by step S**131**.

In the second scenario, the base station **200***a* which has received the handover request confirm message first increases the number of resource blocks to be allocated to the user equipment **100** in at least one component carrier. The amount of communication resources available for the user equipment **100** thereby increases temporarily (step S**131**). After that, the base station **200***a* transmits data to the user equipment **100** at a rate exceeding a normal data rate by using the temporarily increased communication resources (step S**134**). The transmitted data is temporarily accumulated in the buffer **152** of the user equipment **100**. Then, in the same procedure as in the first scenario, after the number of component carriers constituent of the communication channel between the user equipment **100** and the base station **200***a* is shrunk to one, a handover from the base station **200***a* to the base station **200***b* is carried out. The radio communication involving the carrier aggregation is then restarted between the user equipment **100** and the base station **200***b*.

(3-4. Summary of First Embodiment)

The first embodiment of the present invention is described above with reference to FIGS. **4** to **8**. According to the embodiment, before a handover command is transmitted from the source base station to the user equipment, the number of component carriers constituent of the communication channel between the user equipment and the source base station is shrunk to one. It is thereby possible to carry out the procedure from transmission of a handover command to completion of a handover in the same procedure as the existing handover procedure.

Further, according to the embodiment, before the number of component carriers is shrunk to one, the amount of communication resources allocated to the user equipment is temporarily increased, and data is transmitted to the user equip-

ment at a rate exceeding a normal data rate by using the communication resources. It is thereby possible to reduce the possibility of the occurrence of a failure caused by buffer under flow in the user equipment during the period until the user equipment restarts carrier aggregation with the target base station. Further, a temporary increase in the amount of communication resources can be made by an increase in the number of component carriers or an increase in the number of resource blocks. Because the increase in the number of component carriers and the increase in the number of resource blocks can be made by applying the existing scheme, the impact of such processing on the whole system is small. Further, in this embodiment, because a change in the number of component carriers is made under control of the base station, the impact on the user equipment, particularly, can be minimized.

Note that, in the step S**134** of FIGS. **7** and **8**, data may be transmitted from the user equipment to the base station, rather than transmitted from the base station to the user equipment at a rate exceeding a normal data rate by using the temporarily increased communication resources. In this case, in the user equipment that transmits contents to another equipment, a large amount of content data is transmitted in advance before the shrinkage of the number of component carriers, for example, thereby avoiding the occurrence of buffer over flow during the handover procedure.

4. Description of Second Embodiment

A second embodiment of the present invention is described hereinafter with reference to FIGS. **9** to **12**.

(4-1. Exemplary Configuration of User Equipment)

FIG. **9** is a block diagram showing an example of a configuration of a user equipment **300** according to the embodiment. Referring to FIG. **9**, the user equipment **300** includes a radio communication unit **110**, a signal processing unit **150**, a buffer **152**, a control unit **360**, and a measurement unit **170**.

(Control Unit)

The control unit **160** controls the overall functions of the user equipment **300** by using a processing device such as a CPU or a DSP. For example, the control unit **360** controls the timing of data communication by the radio communication unit **110** according to scheduling information that is received from a base station **400** by the radio communication unit **110**. Further, as the preliminary step toward a handover, the control unit **360** shrinks the number of component carriers constituent of a communication channel with the base station **400** to one. The control unit **360** may shrink the number of component carriers before transmitting a measurement report to the base station **400** when a result of the measurement by the measurement unit **170** indicates that a handover should be started, for example. In this embodiment, the control unit **360** transmits a shrink request to the base station **400** and, after the shrink request is confirmed by the base station **400**, the control unit **360** shrinks the number of component carriers to one. Further, before shrinking the number of component carriers to one, the control unit **360** temporarily increases the amount of communication resources available for the user equipment **300**. The control unit **360** may temporarily increase the amount of communication resources available for the user equipment **300** by increasing the number of component carriers constituent of the communication channel with the base station **400**, for example. Alternatively, the base station **400** which has received the shrink request may temporarily increase the number of resource blocks to be allocated to the user equipment **300** in at least one component carrier. After the control unit **360** transmits or receives data at a higher data rate than usual by using the communication resources which are increased in this manner and further shrinks the number of component carriers to one, the control unit **360** transmits a measurement report to the base station **400**. After that, the control unit **360** controls the user equipment **300** to operate in the same manner as the user equipment in the handover procedure which is descried with reference to FIG. **1**.

(4-2. Exemplary Configuration of Base Station]

FIG. **10** is a block diagram showing an example of a configuration of the base station **400** according to the embodiment. Referring to FIG. **10**, the base station **400** includes a radio communication unit **210**, an interface unit **250**, a CC management unit **260**, and a control unit **480**.

(Control Unit)

The control unit **480** controls the overall functions of the base station **400** by using a processing device such as a CPU or a DSP. For example, the control unit **480** allocates communication resources for data communication to the user equipment **300** and other user equipments and then delivers scheduling information over a broadcast channel in a given sub-frame.

Further, in this embodiment, in the case where the base station **400** is a source base station, the control unit **480** receives the above-described shrink request from the user equipment **300** through the radio communication unit **210**. Further, before or after receiving the shrink request, the control unit **480** temporarily increases the amount of communication resources to be allocated to the user equipment **300** in response to a request from the user equipment **300**. The control unit **480** may increase the above-described amount of communication resources by increasing the number of component carriers constituent of the communication channel with the user equipment **300**, for example. Alternatively, the control unit **480** may increase the above-described amount of communication resources by increasing the number of resource blocks to be allocated to the user equipment **300** in at least one component carrier, for example. After the control unit **480** transmits/receives data to/from the user equipment **300** at a higher rate than usual by using the communication resources which are increased in this manner, the control unit **480** confirms the shrink request from the user equipment **300**. As a result, the number of component carriers constituent of the communication channel between the user equipment **300** and the base station **400** is shrunk to one. Then, the control unit **480** carries out a handover for one component carrier after the shrinkage.

Further, in the case where the base station **400** is a target base station, when a handover by the user equipment **300** is completed, the control unit **480** restarts the radio communication involving the carrier aggregation by the user equipment **300** in response to a request from the user equipment **300**.

(4-3. Flow of Process)

Two scenarios of a handover procedure according to the embodiment are described hereinbelow. Note that, in the following scenarios, it is assumed that a handover procedure is performed among the user equipment **300**, the base station **400***a* serving as a source base station, and the base station **400***b* serving as a target base station. Further, for the procedure up to measurement in the user equipment (steps S**2** to S**14**) in the typical handover procedure illustrated in FIG. **1**, explanation is omitted because there is no significant difference.

FIG. **11** is a sequence chart showing an example of a flow along the first scenario of a handover procedure according to the embodiment. Referring to FIG. **11**, the user equipment **300** first makes a random access to the base station **400***a* for

a new component carrier to establish a communication channel with the base station **400***a* and thereby increases the number of component carriers (step S**212**). After that, the base station **400***a* transmits data to the user equipment **300** at a rate exceeding a normal data rate over the expanded communication channel (step S**214**). The transmitted data is temporarily accumulated in the buffer **152** of the user equipment **300**. Note that, in the step S**214**, data may be received from the user equipment **300** rather than transmitted to the user equipment **300**.

After the sufficient amount of data to avoid buffer under flow are accumulated in the buffer **152**, for example, the user equipment **300** transmits a shrink request to the base station **400***a* (step S**216**). Then, the base station **400***a* transmits a confirm message for the shrink request to the user equipment **300** (step S**222**). The user equipment **300** then shrinks the number of component carriers constituent of the communication channel with the base station **400***a* to one (step S**224**).

Then, the user equipment **300** transmits a measurement report for one component carrier after the shrinkage to the base station **400***a* (step S**232**). Receiving the measurement report, the base station **400***a* transmits a handover request message to the base station **400***b* (step S**234**). Receiving the handover request message, the base station **400***b* determines whether it is possible to accept the user equipment **300** according to the availability of a communication service offered by itself or the like. When the base station **400***b* determines that it is possible to accept the user equipment **300**, it transmits a handover request confirm message to the base station **400***a* (step S**236**). Receiving the handover request confirm message, the base station **400***a* transmits a handover command to the user equipment **300** (step S**242**).

Receiving the handover command, the user equipment **300** continues the handover procedure for one component carrier after the shrinkage. Specifically, the user equipment **300** first acquires synchronization with the downlink channel of the base station **400***b* (step S**252**). Then, the user equipment **300** makes a random access to the base station **400***b* by using a random access channel in a given time slot of the synchronized downlink channel (step S**254**). During this period, the base station **400***a* forwards data addressed to the user equipment **300** to the base station **400***b* (step S**256**). Then, after success in the random access, the user equipment **300** transmits a handover complete message to the base station **400***b* (step S**262**). Receiving the handover complete message, the base station **400***b* requests the MME to perform route update for the user equipment **300** (step S**264**). Then, the base station **400***b* transmits acknowledgement for the handover complete message to the user equipment **300** (step S**266**).

After that, the user equipment **300** restarts the radio communication involving the carrier aggregation with the base station **400***b*, which is a new serving base station (step S**280**). Specifically, the user equipment **300** makes a random access to the base station **400***b* for an additional component carrier to establish a communication channel with the base station **400***b*, for example, and thereby increases the number of component carriers. It is thereby possible in the user equipment **300** to use the communication service again at substantially the same data rate as that before the start of the handover procedure.

FIG. **12** is a sequence chart showing an example of a flow along the second scenario of a handover procedure according to the embodiment. As is understood from comparison between FIG. **11** and FIG. **12**, in the second scenario, the steps S**212** to S**222** in the first scenario are replaced by steps S**216** to S**222**.

In the second scenario, the user equipment **300** which has recognized that a measurement result indicates that a handover should be started transmits a shrink request to the base station **400***a* (step S**216**). Receiving the shrink request, the base station **400***a* increases the number of resource blocks to be allocated to the user equipment **300** in at least one component carrier. The amount of communication resources available for the user equipment **300** thereby increases temporarily (step S**218**). After that, the base station **400***a* transmits data to the user equipment **300** at a rate exceeding a normal data rate by using the temporarily increased communication resources (step S**220**). The transmitted data is temporarily accumulated in the buffer **152** of the user equipment **300**. After that, the base station **400***a* transmits a confirm message for the shrink request to the user equipment **300** (step S**222**). Then, in the same procedure as in the first scenario, after the number of component carriers constituent of the communication channel between the user equipment **300** and the base station **400***a* is shrunk to one, a handover from the base station **400***a* to the base station **400***b* is carried out. The radio communication involving the carrier aggregation is then restarted between the user equipment **300** and the base station **400***b*.

(4-4. Summary of Second Embodiment)

The second embodiment of the present invention is described above with reference to FIGS. **9** to **12**. According to the embodiment, before a measurement report is transmitted from the user equipment to the source base station, the number of component carriers constituent of the communication channel between the user equipment and the source base station is shrunk to one. It is thereby possible to carry out the procedure from transmission of a measurement report to completion of a handover in the same procedure as the existing handover procedure.

Further, in this embodiment also, before the number of component carriers is shrunk to one, the amount of communication resources allocated to the user equipment is temporarily increased, and data is transmitted and received at a rate exceeding a normal data rate by using the communication resources. It is thereby possible to reduce the possibility of the occurrence of a failure caused by buffer under flow or buffer over flow in the user equipment during the period until the user equipment restarts carrier aggregation with the target base station. Further, in this embodiment, because a change in the number of component carriers is made in response to a request from the user equipment, the impact on the base station, particularly, can be minimized.

5. Description of Third Embodiment

A third embodiment of the present invention is described hereinafter with reference to FIGS. **13** to **15**.

(5-1. Exemplary Configuration of User Equipment)

FIG. **13** is a block diagram showing an example of a configuration of a user equipment **500** according to the embodiment. Referring to FIG. **13**, the user equipment **500** includes a radio communication unit **110**, a signal processing unit **150**, a buffer **152**, a control unit **560**, and a measurement unit **170**.

(Control Unit)

The control unit **560** controls the overall functions of the user equipment **500** by using a processing device such as a CPU or a DSP. For example, the control unit **560** controls the timing of data communication by the radio communication unit **110** according to scheduling information that is received from a base station **600** by the radio communication unit **110**. Further, as the preliminary step toward a handover, the control unit **560** shrinks the number of component carriers constitu-

ent of a communication channel with a source base station to one. Further, after completing a handover for one component carrier after the shrinkage, the control unit **560** temporarily receives an allocation of many communication resources from a target base station and performs data communication at a rate exceeding a normal data rate.

(5-2. Exemplary Configuration of Base Station)

FIG. **14** is a block diagram showing an example of a configuration of the base station **600** according to the embodiment. Referring to FIG. **14**, the base station **600** includes a radio communication unit **210**, an interface unit **250**, a CC management unit **260**, and a control unit **680**.

(Control Unit)

According to some embodiments, the control unit is further configured to adjust a timing of a handover to compensate for a decrease in data throughput due to the reduction of the plurality of component carriers to one. In further embodiments, the timing of the hand over is decided based on a likelihood of success in a random access.

The control unit **680** controls the overall functions of the base station **600** by using a processing device such as a CPU or a DSP. For example, the control unit **680** allocates communication resources for data communication to the user equipment **500** and other user equipments and then delivers scheduling information over a broadcast channel in a given sub-frame.

Further, in this embodiment, in the case where the base station **600** is a source base station, when a handover request is confirmed by a target base station, the control unit **680** transmits a shrink command to the user equipment **500** before transmitting a handover command. The number of component carriers constituent of the communication channel between the user equipment **500** and the base station **600** is thereby shrunk to one. Then, the control unit **680** transmits a handover command for one component carrier after the shrinkage to the user equipment **500**.

Further, in this embodiment, in the case where the base station **600** is a target base station, when a handover request is received from a source base station, the control unit **680** monitors the availability of communication resources. Then, the control unit **680** adjusts the timing to confirm the handover request from the source base station so that a decrease in throughput due to the shrinkage of the number of component carriers is suppressed or compensated.

Specifically, when a random access from the user equipment **500** is success, for example, the control unit **680** confirms the handover request after waiting until the timing at which a sufficient amount of communication resources can be allocated to the user equipment **500**. The sufficient amount may be the amount of communication resources which enables an allocation of substantially the same number of component carries as the number of component carriers before the handover (shrinkage) to a new communication channel, for example. In this case, by recovering the number of component carriers promptly after the handover, it is possible to reduce the time during which a throughput decreases due to the handover. Note that the number of component carriers before the handover can be notified from the source base station to the target base station by advance negotiation or using a handover request message or another message, for example.

Further, the sufficient amount may be the amount of communication resources which enables a recovery of the amount of data accumulated in the buffer of the user equipment at the receiving end of data to the amount not causing buffer under flow, for example. The amount of communication resources may be defined in advance, or notified from a source base station by using a handover request message or the like. In this case, after a random access from the user equipment **500** succeeds, the amount of communication resources allocated to the user equipment **500** is temporarily increased, thereby compensating a decrease in throughput that occurs due to the shrinkage of the number of component carriers.

Furthermore, the control unit **680** may confirm the handover request after waiting until the timing at which it is determined that the possibility of success in a random access from the user equipment **500** is high. An example of the timing when the possibility of success in a random access is high is timing at which there are not a large number of other user equipments that are trying to make a random access (e.g. another user equipment that has started a handover, a user equipment in the idle mode etc.). In this case, it is possible to prevent a delay of a handover caused by a failure and retry of a random access and reduce the time during which a throughput decreases due to the handover.

(5-3. Flow of Process)

An example of a flow of a handover procedure according to the embodiment is described hereinbelow. Note that, in the following scenario, it is assumed that a handover procedure is performed among the user equipment **500**, the base station **600***a* serving as a source base station, and the base station **600***b* serving as a target base station. Further, for the procedure up to measurement in the user equipment (steps S**2** to S**14**) in the typical handover procedure illustrated in FIG. **1**, explanation is omitted because there is no significant difference.

FIG. **15** is a sequence chart showing an example of a flow of a handover procedure according to the embodiment. Referring to FIG. **15**, the user equipment **500** first transmits a measurement report for a plurality of component carriers constituent of a communication channel to the base station **600***a* (step S**322**). The base station **600***a* which has determined that a handover is necessary based on the measurement report transmits a handover request message to the base station **600***b* (step S**324**). Receiving the handover request message, the base station **600***b* adjusts the timing to confirm the handover request so that a decrease in throughput due to the shrinkage of the number of component carriers is suppressed or compensated. (step S**325**). Then, the base station **600***b* transmits a handover request confirm message to the base station **600***a* at timing (T1) when the subsequent random access is likely to succeed, timing (T2) when more communication resources can be allocated after completion of a handover, or timing (T3) when carrier aggregation can be restarted promptly after completion of a handover, for example (step S**326**).

Receiving the handover request confirm message, the base station **600***a* transmits a shrink command for decreasing the number of component carriers to the user equipment **500** (step S**336**). After that, the user equipment **500** shrinks the number of component carriers constituent of the communication channel with the base station **600***a* to one (step S**340**). The base station **600***a* then transmits a handover command for one component carrier after the shrinkage to the user equipment **500** (step S**342**).

Receiving the handover command, the user equipment **500** continues the handover procedure for one component carrier after the shrinkage. Specifically, the user equipment **500** first acquires synchronization with the downlink channel of the base station **600***b* (step S**352**). Then, the user equipment **500** makes a random access to the base station **600***b* by using a random access channel in a given time slot of the synchronized downlink channel (step S**354**). During this period, the base station **600***a* forwards data addressed to the user equip-

ment **500** to the base station **600***b* (step S**356**). Then, after success in the random access, the user equipment **500** transmits a handover complete message to the base station **600***b* (step S**362**). Receiving the handover complete message, the base station **600***b* requests the MME to perform route update for the user equipment **500** (step S**364**). Then, the base station **600***b* transmits acknowledgement for the handover complete message to the user equipment **500** (step S**366**).

After that, the base station **600***b* temporarily allocates a larger number of resource blocks to the user equipment **500**, for example (step S**370**). Then, the base station **600***b* transmits data to the user equipment **500** at a rate exceeding a normal data rate (step S**372**). The transmitted data recovers the amount of data which has decreased during the handover procedure in the buffer **152** of the user equipment **500**. Note that, in the step S**372**, data may be received from the user equipment **500**, rather than transmitted to the user equipment **500**. After that, the user equipment **500** restarts the radio communication involving the carrier aggregation with the base station **600***b*, which is a new serving base station (step S**380**).

(5-4. Summary of Third Embodiment)

The third embodiment of the present invention is described above with reference to FIGS. **13** to **15**. According to the embodiment, before a handover command is transmitted from a source base station to a user equipment, the number of component carriers constituent of the communication channel between the user equipment and the source base station is shrunk to one. It is thereby possible to carry out the procedure from transmission of a handover command to completion of a handover in the same procedure as the existing handover procedure.

Further, in this embodiment, after success in a random access from a user equipment to a target base station, the amount of communication resources allocated to the user equipment is temporarily increased in the target base station. Then, by using the communication resources, data is transmitted/received to/from the user equipment at a rate exceeding a normal data rate. It is thereby possible to compensate a decrease in throughput that occurs due to the shrinkage of the number of component carriers.

Furthermore, in this embodiment, the timing to confirm the handover request in the target base station is adjusted so as to suppress or compensate a decrease in throughput due to the shrinkage of the number of component carriers. It is thereby possible to reduce the possibility that a failure occurs in a communication service such as contents delivery due to a decrease in throughput.

Although preferred embodiments of the present invention are described in detail above with reference to the appended drawings, the present invention is not limited thereto. It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

REFERENCE SIGNS LIST

1 RADIO COMMUNICATION SYSTEM
100, **300**, **500** USER EQUIPMENT
110 RADIO COMMUNICATION UNIT (USER EQUIPMENT)
160, **360**, **560** CONTROL UNIT (USER EQUIPMENT)
200, **400**, **600** BASE STATION
210 RADIO COMMUNICATION UNIT (BASE STATION)
280, **480**, **680** CONTROL UNIT (BASE STATION)

The invention claimed is:

1. An electronic device comprising:
circuitry configured to
control transmitting or receiving signals via a plurality of component carriers;
determine whether to conduct handover based on a measurement report received from a terminal device; and
transmit, after determining to conduct the handover and before forwarding data addressed to the terminal device to a target base station, a deactivation command to the terminal device commanding the terminal device to deactivate all except for one of the plurality of component carriers.

2. The electronic device of claim **1**, wherein the circuitry is configured to:
transmit a handover request to the target base station after determining to conduct the handover;
receive a handover request acknowledgement in response to the handover request; and
transmit the deactivation command after receiving the handover request acknowledgement.

3. The electronic device of claim **2**, wherein
the circuitry is configured to transmit a handover command to change a synchronizing component carrier from the one of the plurality of component carriers to another component carrier.

4. The electronic device of claim **3**, wherein
the terminal device sends a random access preamble to the target base station via the another component carrier.

5. The electronic device of claim **4**, wherein
the terminal device starts communication with the target base station via only the one of the plurality of component carriers.

6. The electronic device of claim **4**, wherein the deactivation command is transmitted before the random access preamble is sent.

7. A communication control apparatus comprising:
one or more antennas; and
circuitry configured to
control transmitting or receiving signals via a plurality of component carriers;
determine whether to conduct handover based on a measurement report received from a terminal device; and
transmit, after determining to conduct the handover and before forwarding data addressed to the terminal device to a target base station, a deactivation command to the terminal device commanding the terminal device to deactivate all except for one of the plurality of component carriers.

8. The communication control apparatus of claim **7**, wherein the circuitry is configured to:
transmit a handover request to the target base station after determining to conduct the handover;
receive a handover request acknowledgement in response to the handover request; and
transmit the deactivation command after receiving the handover request acknowledgement.

9. The communication control apparatus of claim **8**, wherein
the circuitry is configured to transmit a handover command to change a synchronizing component carrier from the one of the plurality of component carriers to another component carrier.

10. The communication control apparatus of claim **9**, wherein
the terminal device sends a random access preamble to the target base station via the another component carrier.

11. The communication control apparatus of claim 10, wherein

the terminal device starts communication with the target base station via only the one of the plurality of component carriers.

12. The communication control apparatus of claim 10, wherein

the deactivation command is transmitted before the random access preamble is sent.

13. The communication control apparatus of claim 7, further comprising:

a plurality of filters configured to perform band limitation.

14. A communication control method comprising:

controlling transmitting or receiving signals via a plurality of component carriers;

determining whether to conduct handover based on a measurement report received from a terminal device; and

transmitting, after determining to conduct the handover and before forwarding data addressed to the terminal device to a target base station, a deactivation command to the terminal device commanding the terminal device to deactivate all except for one of the plurality of component carriers.

15. The method of claim 14, further comprising:

transmitting a handover request to the target base station after determining to conduct the handover;

receiving a handover request acknowledgement in response to the handover request; and

transmitting the deactivation command after receiving the handover request acknowledgement.

16. The method of claim 14, further comprising:

transmitting a handover command to change a synchronizing component carrier from the one of the plurality of component carriers to another component carrier.

17. The method of claim 16, wherein

the terminal device sends a random access preamble to the target base station via the another component carrier.

18. The method of claim 17, wherein

the terminal device starts communication with the target base station via only the one of the plurality of component carriers.

19. The method of claim 17, wherein

the deactivation command is transmitted before the random access preamble is sent.

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